This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

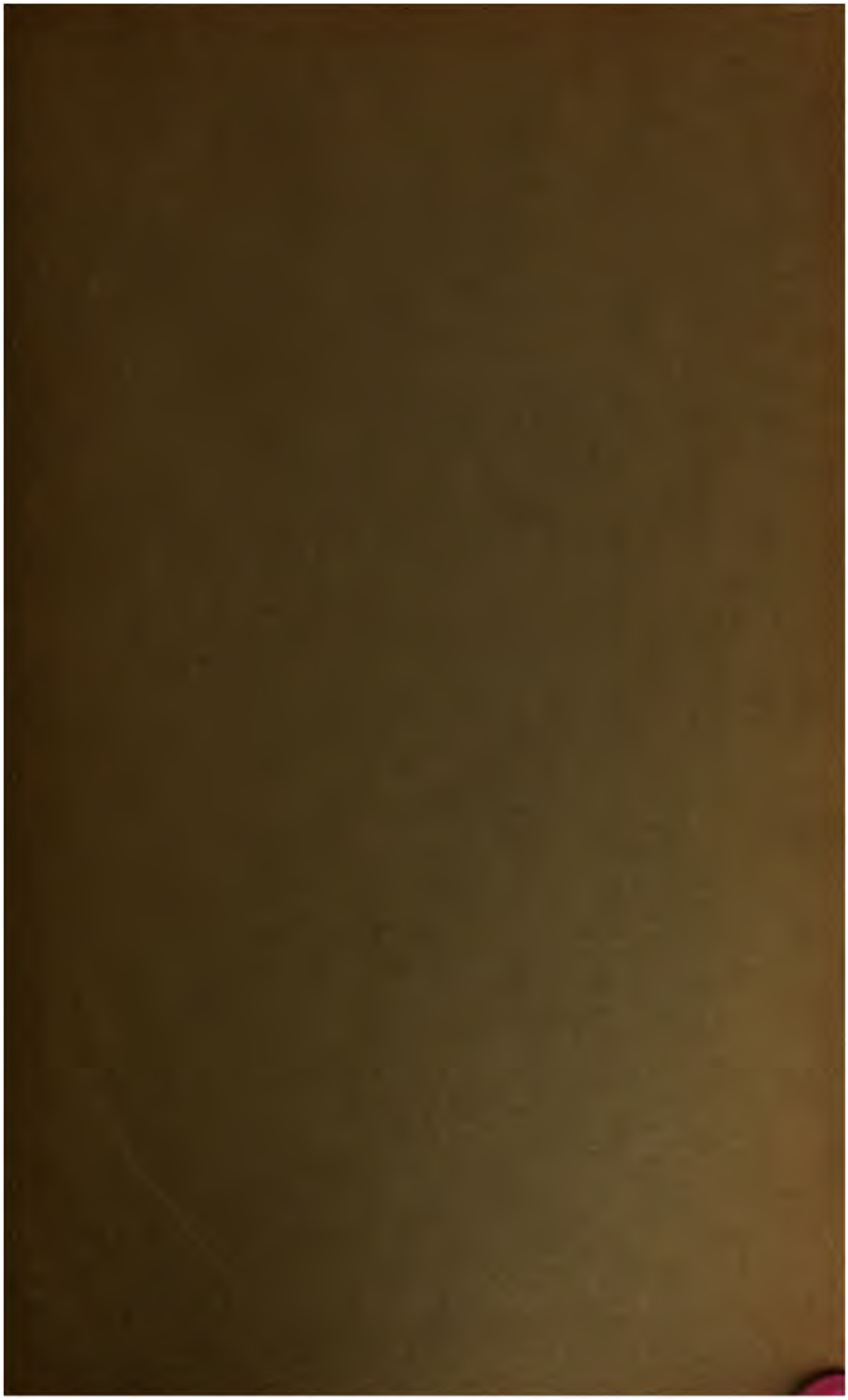
+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

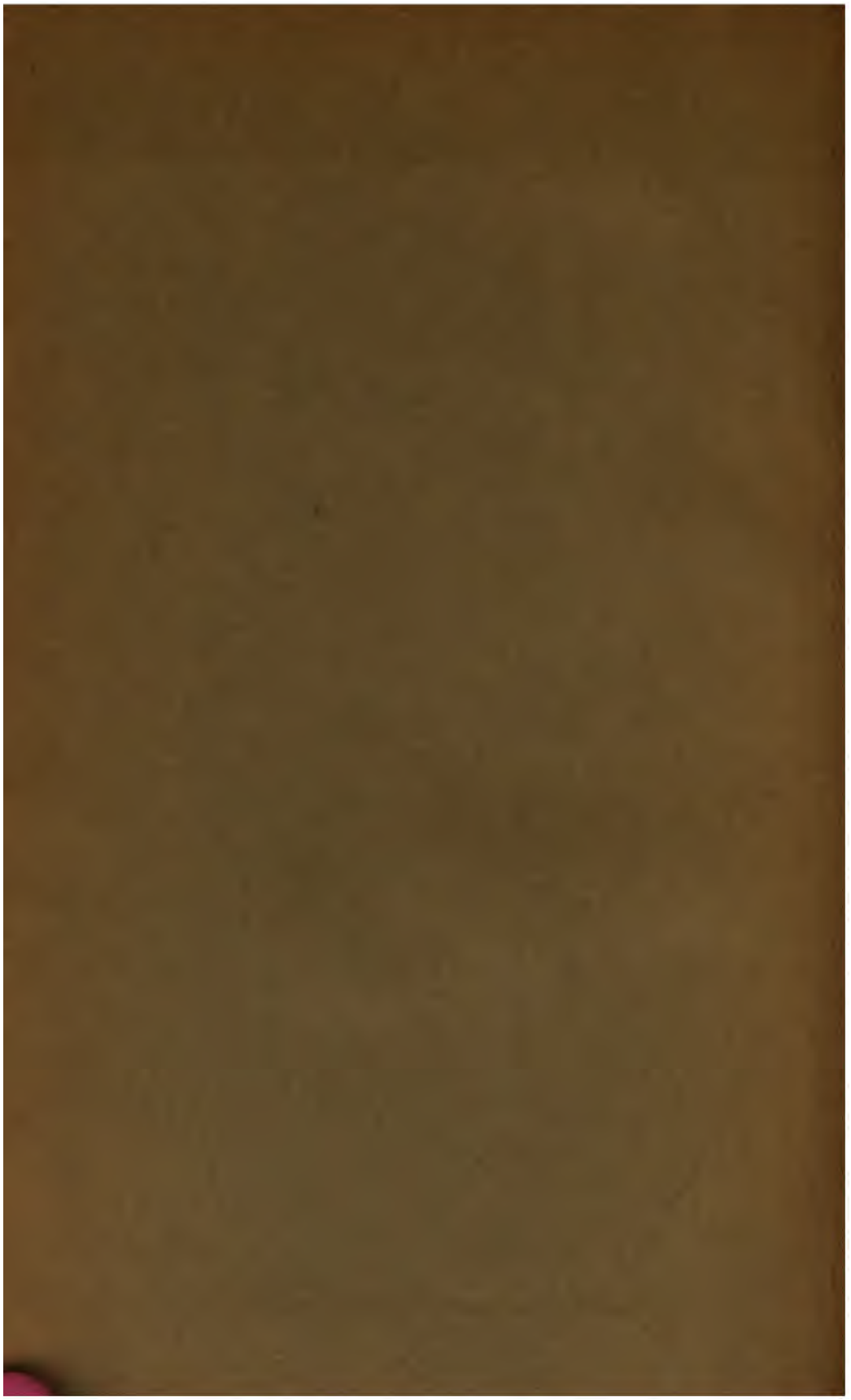
About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

HARVARD UNIVERSITY

LIBRARY OF THE
MINERALOGICAL
LABORATORY
UNIVERSITY MUSEUM





Water-Supply and Irrigation Paper No. 120 Series O, Underground Waters, 34

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

BIBLIOGRAPHIC REVIEW AND INDEX

OF

PAPERS RELATING TO UNDERGROUND WATERS

PUBLISHED BY THE

UNITED STATES GEOLOGICAL SURVEY

1879-1904

BY

MYRON L. FULLER

WASHINGTON
GOVERNMENT PRINTING OFFICE
1905

CONTENTS.

	Page.
Letter of transmittal	5
Introduction	7
Bibliographic review	9
Classified key to principal subject entries in index	95
Index	101

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
HYDROGRAPHIC BRANCH,
Washington, D. C., February 21, 1905.

SIR: I transmit herewith a manuscript entitled "Bibliographic Review and Index of Papers Relating to Underground Waters published by the United States Geological Survey, 1879–1904," prepared by Myron L. Fuller, geologist in charge of the eastern section, division of hydrology, to meet the urgent need for definite information as to what has been accomplished by the Survey in the line of underground-water investigations and what has appeared in Survey publications bearing on the subject.

Very respectfully,

F. H. NEWELL,
Chief Engineer.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

BIBLIOGRAPHIC REVIEW AND INDEX OF PAPERS RELATING TO UNDERGROUND WATERS PUBLISHED BY THE UNITED STATES GEOLOGICAL SURVEY, 1879–1904.

By MYRON L. FULLER.

INTRODUCTION.

On the organization of the division of hydrology in 1903, and the beginning of systematic work on underground waters, an urgent need was felt for more definite information as to what had been published on the subject by both the National and the State surveys and in other publications. Plans were accordingly made for preparing a bibliography of underground waters, but it was soon found that owing to inadequate indexes it would be necessary to scan nearly every page of geologic publications. As this was not feasible, it became necessary to limit the work, for the time at least, to the preparation of a review and index of the publications of the United States Geological Survey.

These publications, amounting to about 400 volumes and embracing about 1,500 papers, were examined, many of them page by page, and brief summaries of the facts relating to underground waters were compiled. A large proportion of the references to underground waters are given in connection with geologic descriptions, and most of them are very brief, although some are of importance. Being incidental to discussions of other subjects, many would doubtless be ordinarily overlooked, especially as in a large number of cases no reference is made to them in the indexes. There are about 600 titles in the bibliography, an average of about 21 for each year from 1880 to 1903, but in 1904, owing to the publication of the results of the systematic work of the new division of hydrology, this number was increased to about 130.

In preparing the index two distinct classes of readers were kept in mind, the first including those who are interested in the underground-water resources of special regions, and the second those interested in some particular type of ground water or in one or more of the many problems of ground-water occurrence. For the benefit of the first,

comprehensive entries are given under States and other political or natural divisions, while for the benefit of the second are given the numerous subject entries. The aim has been to assemble the latter entries into comprehensive groups, each including references to papers containing material bearing on the subject of the group. The State entries will be found the most complete, as they include many which it is impossible to satisfactorily classify.

The subject entries are grouped mainly into a series of what may be termed principal subject entries, which are outlined in the "Classified key to principal subject entries in index," but a large number of other entries, including those which it was impracticable to classify and numerous cross references, are included with the view of increasing the usefulness of the index.

The general plan followed is the same as that of the geologic bibliographies of Mr. F. B. Weeks, which more nearly meet the demands of the user than any other publications of the kind seen by the writer. The principal point of difference is the omission of the abbreviated titles in the index of the present bibliography, due to the fact that the titles of the papers in most cases express little or nothing as to their contents in respect to underground-water descriptions or discussions. On the other hand, the present bibliography attempts to give, in connection with the titles, summaries indicating in considerable detail the nature of the portion of the contents bearing on underground waters.

BIBLIOGRAPHIC REVIEW.

A.

1 **Adams** (George I.). Preliminary report on the lead and zinc deposits of the Ozark region: Physiography.

U. S. Geol. Surv., 22d Ann. Rept., pt. 2, pp. 69–75, 1901.

Mentions the springs of the Ozark Plateau and Boston Mountains.

2 —— Oil and gas fields of the Western Interior and Northern Texas Coal Measures.

U. S. Geol. Surv., Bull. no. 184, pp. 1–29, 1901.

Contains references to and partial sections of a large number of water, oil, and gas wells.

3 —— Oil and gas fields of the Upper Cretaceous and Tertiary formations of the Western Gulf coast.

U. S. Geol. Surv., Bull. no. 184, pp. 31–62, 1901.

Mentions salt springs (p. 39), gives logs of wells (pp. 57–59), and discusses the association of petroleum, sulphur, gypsum, rock salt, and saline and sulphur waters (pp. 49–53).

4 —— Geology and water resources of the Patrick and Goshen Hole quadrangles in eastern Wyoming and western Nebraska..

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 70, pp. 50, 1902.

Describes the geology, physiography, and drainage, including streams, ponds, and springs. The springs mainly seep out and are of small volume, but occur at several horizons (pp. 27–28). Deep pump wells are obtained from near contact of Arikaree and Brule Clays (pp. 29–30), and some water is afforded by the Cretaceous, although it is likely to be alkaline or salty (p. 30). The seepage waters are also highly mineralized (p. 30).

5 —— Zinc and lead deposits of northern Arkansas.

U. S. Geol. Surv., Bull. no. 213, pp. 187–196, 1903.

Discusses the character of solutions and the circulation of ground water in shales, limestones, and dolomites with relation to ore deposits (pp. 190–192).

6 —— Zinc and lead deposits of northern Arkansas.

U. S. Geol. Surv., Professional Paper no. 24, pp. 1–89, 1904.

Notes the action of underground waters in ore deposition (p. 32), and discusses the geological factors affecting the circulation (pp. 34–36). The part of waters in ore deposition is further discussed on pages 44–46, and the circulation on page 89. J. C. Branner is quoted on the formation of breccias by underground waters (p. 87).

7 **Adams** (George I.). The Rabbit Hole sulphur mines near Humboldt House, Nevada.

U. S. Geol. Surv., Bull. no. 225, pp. 497–500, 1904.

Describes the occurrence of hot springs and silicious sinter in the region, and associates the deposition of sulpur with such ascending waters (p. 499).

8 **Ahern** (Jeremiah). Investigations in northern Wyoming.

U. S. Geol. Surv., 2d Ann. Rept. Reclamation Service 1902–3, pp. 507–528, 1904.

Notes the occurrence of springs near Lake De Smet (p. 515).

9 **Alden** (William C.). Chicago folio. Illinois-Indiana.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 81, pp. 13, 1902.

Gives a number of deep-well sections (pp. 2–3) and discusses the water supplies of the drift and of the rock wells in the Potsdam and St. Peters sandstones and Trenton limestone. Analyses are given. The wells originally gave strong flows, but because of the large number drilled the water head has been lowered to 15 to 20 feet below the surface (p. 13).

10 **Ayers** (H. B.). The Flathead Forest Reserve, Montana.

U. S. Geol. Surv., 20th Ann. Rept., pt. 5, pp. 245–316, 1899.

Notes the disappearance of streams from the surface by absorption (p. 261).

B.

11 **Bain** (H. Foster). Preliminary report on the lead and zinc deposits of the Ozark region.

U. S. Geol. Surv., 22d Ann. Rept., pt. 2, pp. 33–227, 1901.

Contains a chapter on the relation of ores to the circulation of underground waters, in which general principles, circulation, courses of underground waters, structural conditions, work of underground waters, including solution, precipitation, diffusion, etc., are considered (pp. 95–110). The ores were in part deposited by ascending waters, in part by descending, and in part deposited by ascending and concentrated by descending waters (p. 203). The relation of the ores to underground circulation is also discussed (pp. 204–207).

12 —— Lead and zinc deposits of Illinois.

U. S. Geol. Surv., Bull. no. 225, pp. 202–207, 1904.

Notes burden imposed on mines by underground water (p. 203), and discusses the relation of underground waters to ore deposition (p. 206).

13 —— Fluorspar deposits of southern Illinois.

U. S. Geol. Surv., Bull. no. 225, pp. 505–511, 1904.

Discusses relation of underground waters to ore deposition (p. 510).

14 **Barbour** (Erwin Hinckley). Wells and windmills of Nebraska.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 29, pp. 85, 1899.

Among the subjects discussed are underground-water conditions (pp. 13–16), sheet water (pp. 17–18), artesian waters and well records (pp. 18–24), springs (p. 24), surface and seepage waters (p. 27), fluctuations of water level (p. 28), windmills, turbines, and other methods of raising waters (pp. 28–70), well supplies for towns and cities (pp. 73–75), salt wells (p. 78), and blowing, breathing, and sucking wells (pp. 78–80).

15 **Barker** (F. C.). Irrigation in Mesilla Valley, New Mexico.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 10, pp. 51, 1898.

The occurrence and source of the ground water in Mesilla Valley (pp. 18–19) and the relative efficiency and cost of bringing it to the surface by wind and steam power (pp. 35–36) are considered.

16 **Bascom** (Florence). Water resources of the Philadelphia district.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 106, pp. 75, 1904.

This paper contains detailed discussions of geology, rainfall, stream measurements, water powers, wells, springs, and public supplies, including those from streams, wells, and springs. Among the geological formations yielding water to wells are the Chickies quartzite, Chester Valley limestone, Wissahickon gneiss, Triassic rocks, and Raritan, Matawan, and Monmouth formations, etc.

17 **Bayley** (William Shirley). The Menominee iron-bearing districts of Michigan.

U. S. Geol. Surv., Mon. 46, pp. 513, 1904.

Notes the relation of descending meteoric water to ores (pp. 27–29), and quotes C. Rominger on action of percolating waters and D. H. Browne on aqueous origin of ores (pp. 90–91). The action of percolating waters, either ascending or descending, is considered in connection with ores in the Randville dolomite (p. 224), the origin of cherts (p. 231), and in the deposition or enrichment of Algonkian ores (pp. 395–401).

18 —— Maine. [Well and spring records.]

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 102, pp. 27–55, 1904.

Discusses the general underground-water conditions (pp. 27–28), and gives tables and notes of wells (pp. 29–47) and springs (pp. 47–55). The well statistics include data on elevation, temperature, analyses, and uses, and the spring statistics data on temperature, quality, analyses, yield, and uses.

19 **Becker** (George F.). Administrative report [1879-80].

U. S. Geol. Surv., 1st Ann. Rept., pp. 37–47, 1880.

Discusses the occurrence, temperatures, and composition of the Comstock mine waters [Nevada].

20 —— Geology of the Comstock lode and the Washoe district, with atlas.

U. S. Geol. Surv., Mon. 3, pp. 422, atlas, 1882.

Analyses of mine waters are given (p. 152) and the hot waters encountered, some of which have a temperature of 170°, are described (pp 228–243). Kaolinization of feldspar, alteration of pyrite, faulting, and solfataric action are considered as sources of heat, most weight being given to the last (pp. 231–243). The water is supposed to have come from a considerable distance, and to have penetrated several miles below the surface (pp. 264 and 387–397).

21 **Becker** (George F.). Geology of the quicksilver deposits of the Pacific coast, with an atlas.

U. S. Geol. Surv., Mon. 13, pp. 486, atlas, 1888.

Among the subjects discussed are the following: Geysers of Iceland (pp. 24–26), heat of thermal springs (p. 441), hot springs in mines (pp. 381–382, 402), association of cinnabar with hot springs (p. 371), sulphur springs (pp. 367, 777), hot springs and their deposits (pp. 50, 52), and origin of ore, solvents, etc. (pp. 438–475). The sinter, ore, and waters of Steamboat Springs (pp. 331–353) and of Sulphur Bank (pp. 251–268) are described and analyses given. The ores are supposed to have been deposited by hot ascending solutions (p. 416).

22 —— Summary of the geology of the quicksilver deposits of the Pacific slope.

U. S. Geol. Surv., 8th Ann. Rept., pt. 2, pp. 961–985, 1889.

Ascribes the heat of the solfataric springs at Sulphur Bank, California, as resulting from basalt eruption. The water carries sulphydric acid, which attacks basalt and deposits sulphur and cinnabar. Discusses composition of the waters and refers deposition to loss of heat and pressure. Some of the veins mark former solfataras (pp. 975–976). The springs of the Knoxville district, Steamboat Springs, and Bailey Point, California, carry alkaline sulphosalts and deposit quicksilver and gold. They are associated with basaltic masses of late geological age. The hot springs at Oat Hill are also mentioned (pp. 976–980).

23 —— Administrative report [1887–88].

U. S. Geol. Surv., 9th Ann. Rept., pp. 100–102, 1889.

Notes the conditions of deposition of cinnabar in hot springs.

24 —— Report of the geology of the Philippine Islands.

U. S. Geol. Surv., 21st Ann. Rept., pt. 3, pp. 487–614, 1900.

In connection with the discussion of volcanoes the warm springs of Panay, the solfataras and hot springs of Albay and their deposits, and the Hot Springs of Los Baños are described (pp. 531–534).

25 **Beede** (J. W.), **Prosser** (Charles S.) and. Cottonwood Falls folio, Kansas.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 109, pp. 6, 1904.

See Prosser (Charles S.) and Beede (J. W.)

26 **Boutwell** (J. M.). Progress report on the Park City mining district, Utah.

U. S. Geol. Surv., Bull. no. 213, pp. 31–40, 1903.

Describes the underground waters encountered in the mines and the collection of the domestic supply from a tunnel (p. 33).

27 —— Ore deposits of Bingham, Utah.

U. S. Geol. Surv., Bull. no. 213, pp. 105–122, 1903.

Notes the occurrence of springs in Bingham Canyon and the tapping of subterranean water courses by the underground workings. The water supply is thus obtained (p. 107).

28 **Boutwell** (J. M.). Progress report on the Park City mining district, Utah.

U. S. Geol. Surv., Bull. no. 225, pp. 141–150, 1904.

Notes difficulties with water in mines and their removal by tunnels (p. 149).

29 —— New Hampshire. [Well and spring records.]

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 102, pp. 56–72, 1904.

Considers briefly the general underground-water conditions (p. 56), and gives tables and notes relating to wells (pp. 57–63) and springs (pp. 64–72). The well statistics include data on yield, quality, composition (with analyses), materials penetrated, uses, etc., and the spring statistics data on source, yield, composition (including analyses), temperature, and uses.

30 **Boyd** (David). Irrigation near Greeley, Colorado.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 9, pp. 90, 1897.

Discusses nature (p. 79), composition (p. 79), and damages by seepage waters at Greeley, and considers remedies (p. 80). The wells in the region above Greeley are described and legal decisions relating to underground waters given. Artesian flows (weak) are obtained at 1,150 feet at Greeley, but underground waters generally fail to reach the surface.

31 **Burchard** (Ernest F.). Lignites of the middle and upper Missouri Valley.

U. S. Geol. Surv., Bull. no. 225, pp. 276–288, 1904.

Gives data relating to borings and well records in Iowa and Nebraska (pp. 277–278, 281).

32 [**Burnett** (Charles A.) and others.] Irrigation literature.

U. S. Geol. Surv., 11th Ann. Rept., pt. 2, pp. 345–388, 1891.

Many of the irrigation papers listed contain references to underground waters and springs.

33 **Burrows** (John Shober). The Barnesboro-Patton coal field of central Pennsylvania.

U. S. Geol. Surv., Bull. no. 225, pp. 295–310, 1904.

Notes occurrence of mine waters (pp. 304, 306).

C.

34 **Campbell** (Marius R.). Richmond folio, Kentucky.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 46, pp. 4, 1898.

Mentions the sulphur, chalybeate, and alum springs of the Chattanooga shale (p. 2), and notes the occurrence of caves, sinks, and underground channels of the Newman limestone (p. 3).

35 —— London folio, Kentucky.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 47, pp. 3, 1898.

The occurreuce of chalybeate, sulphur, and alum springs in the Chattanooga shale, and of sinks, caves, and underground channels in the Newman limestone is mentioned.

36 **Campbell** (Marius R.). Standingstone folio, Tennessee.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 53, pp. 5, 1899.
The oil springs which led to the drilling for oil in the region are described.

37 —— Danville folio, Illinois-Indiana. General geology.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 67, pp. 1–7 (in part), 1900.
Gives a number of deep-well records in connection with the discussion of stratigraphy (p. 2).

38 —— Huntington folio, West Virginia-Ohio.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 69, pp. 6, 1900.
Gives a number of deep-well records (pp. 3–4).

39 —— Charleston folio, West Virginia.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 72, pp. 9, 1901.
Gives several deep-well records (pp. 3–4).

40 —— Raleigh folio, West Virginia.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 77, pp. 8, 1902.
Gives a number of well and boring records and sections (p. 7).

41 —— Masontown-Uniontown folio, Pennsylvania.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 82, pp. 2, 1902.
Gives deep-well record in connection with stratigraphic discussion of the rocks (p. 8).

42 —— [and **Fuller** (Myron L.)]. Natural gas: Petroleum. Masontown-Uniontown folio, Pennsylvania.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 82, pp. 18–20, 1902.
Gives a number of deep-well records and a table showing depths of coal, oil sands, etc., in 24 wells.

43. **Campbell** (Marius R.). Brownsville-Connellsville folio.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 94, pp. 19, 1903.
Gives partial records of several wells (pp. 7–8).

44 —— Latrobe folio, Pennsylvania.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 110, pp. 15, 1904.
Gives a large number of sections based on well records (pp. 5–10) and a sheet of well sections.

45 **Chamberlin** (Thomas C.). The requisite and qualifying conditions of artesian wells.
U. S. Geol. Surv., 5th Ann. Rept., pp. 125–173, 1885.
Embodies descriptions and critical discussions of the lithologic and structural requisites for artesian flows, and considers in some detail the problems of capacity, height of flow, utilization, causes of decrease or failure of flow, arrangement, and testing of wells. The report is illustrated by numerous figures.

46 **Chamberlin** (T. C.) and **Salisbury** (R. D.). Preliminary paper on the Driftless Area of the upper Mississippi Valley.
U. S. Geol. Surv., 6th Ann. Rept., pp. 199–322, 1885.
Mentions artesian wells at La Crosse, Prairie du Chien, Dubuque, etc., and gives thickness of drift penetrated (pp. 223, 303).

47 **Champlin** (F. A.). Additional well records in Massachusetts.
U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 102, pp. 112–117, 1904.
Gives tables showing among other data the depth, supply, and cost of a considerable number of wells located at East Longmeadow and other Massachusetts localities.

48 —— Additional well records in Connecticut.
U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 102, pp. 165–168, 1904.
Gives tables showing among other data the depth, yield, and cost of wells at various Connecticut localities.

49 **Chandler** (Albert E.). Water storage, Cache Creek, California.
U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 45, pp. 48, 1901.
Gives well statistics, including depth, cost, efficiency of pumping, and use for irrigation (pp. 24–26), and describes the artesian well near Woodland and the artesian water of Scotts Valley and Upper Lake (pp. 26, 32).

50 **Chatard** (Thomas M.), **Clarke** (F. W.) and. A report of work done in the Washington laboratory during the fiscal year 1883–84.
See Clarke (F. W.) and Chatard (T. M.)

51 **Chatard** (Thomas M.). Salt-making processes in the United States,
U. S. Geol. Surv., 7th Ann. Rept., pp 491–535, 1888.
Discusses the chemistry of brines from wells and other sources (pp. 498–499), and the product and cost of obtaining salt from brines of different density (pp. 527–529).

52 **Clapp** (Frederick G.), **Fuller** (Myron L.) and. Patoka folio, Indiana-Illinois.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 105, pp. 12, 1904.
See Fuller (Myron L.) and Clapp (Frederick G.).

53 **Clarke** (Frank Wigglesworth) and **Chatard** (Thomas M.). A report of work done in the Washington laboratory during the fiscal year 1883–84.
U. S. Geol. Surv., Bull no. 9, pp. 40, 1884.
Includes a considerable number of water analyses from springs and lakes in California, Montana, Nevada, Oregon, Utah, and Virginia.

54 **Clarke** (F. W.). Administrative report [1883–84].

U. S. Geol. Surv., 5th Ann. Rept., pp. 59–62, 1885.

Gives partial list of thermal spring or geyser waters analyzed at the Survey during the year, including waters from Yellowstone National Park, Montana and Virginia.

55 —— Report of work done in the division of chemistry and physics, mainly during the fiscal year 1884–85.

U. S. Geol. Surv., Bull. no. 27, pp. 80, 1886.

Contains the following analyses (pp. 71–): (1) Incrustation of silica and alumina from gas well in Armstrong County, Pennsylvania (Whitfield); (2) water from Matthews Warm Springs, near Bozeman, Montana (Riggs); (3) water from White Sulphur Springs, Meagher County, Montana (Riggs); and (4) water from mineral spring near Santa Fe, New Mexico (Clarke).

56 —— Report of work done in the division of chemistry and physics, mainly during the fiscal year 1885–86.

U. S. Geol. Surv., Bull. no. 42, pp. 152, 1887.

Contains analyses by R. B. Riggs of waters from two springs near Farmwell Station, Loudoun County, Virginia; from two artesian wells at Story City, Iowa; and from Becks Hot Springs, near Salt Lake City, Utah.

57 —— Administrative report [1885–86].

U. S. Geol. Surv., 7th Ann. Rept., pp. 127–130, 1888.

Describes the work of F. A. Gooch and J. E. Whitfield on spring and geyser waters of the Yellowstone National Park, and announces the discovery of arsenic in the waters. The difficulties of analysis are mentioned.

58 —— Administrative report [1886–87].

U. S. Geol. Surv., 8th Ann. Rept., pt. 1, pp. 189–193, 1889.

Mentions the analysis of 18 spring and well waters, and notes the therapeutic value of the waters of the Yellowstone National Park on account of the boric acid and arsenic which they contain. Designates the studies of Gooch and Whitfield as among the most complete on record.

59 —— Report of work done in the division of chemistry and physics, mainly during the fiscal year 1886–87.

U. S. Geol. Surv., Bull. no. 55, pp. 96, 1889.

Contains analyses of artesian waters in Georgia and Alabama by Riggs; of water from Hot and Potash Sulphur Springs, Arkansas, by Clarke, and of a spring water from near Fort Wingate, New Mexico, by Clarke.

60 —— Report of work done in the division of chemistry and physics, mainly during the fiscal year 1887–88.

U. S. Geol. Surv., Bull. no. 60, pp. 174, 1890.

Analyses of the following waters are given (pp. 171–174): (1) Spring water, Lincoln County, North Carolina (Clarke); spring water, McLeansborough, Illinois (Riggs); (3) deep well water, Lebanon, Missouri, (Eakins); (4) and (5) spring waters, Hominy Hill, Arkansas, (Whitfield); (6) spring water, Denver, Colorado (Eakins), and (7) water from Matilija Hot Springs, near San Buenaventura, California (Riggs).

61 **Clarke** (F. W.). A report of work done in the division of chemistry and physics, mainly during the fiscal year 1888–89.
U. S. Geol. Surv., Bull. no. 64, pp. 60, 1890.
Contains analyses by T. M. Chatard of spring water from Mountain City, Tennessee; spring water from Grace Spring, Laurel Bloomery, Tennessee; water from the Murry Well, Frankfort, Kentucky; from two artesian wells at St. Augustine, Florida, and from wells near Clinton, Massachusetts (pp. 57–60).

62 —— Report of work done in the division of chemistry and physics, mainly during the fiscal year 1889–90.
U. S. Geol. Surv., Bull. no. 78, pp. 131, 1891.
Contains an analyses of a spring water from Webster Grove, near St. Louis, Missruri (Hillebrand and Howard).

63 —— Administrative report.
U. S. Geol. Surv., 13th Ann. Rept., pt. 1, pp. 159–162, 1892.
Describes analysis showing sulphate of zinc in springs in Missouri, and mentions temperature work in deep wells at Wheeling and Crumps Bottom, West Virginia.

64 —— Report of work in the division of chemistry during the fiscal years 1891–92 and 1892–93.
U. S. Geol. Surv., Bull. no. 113, pp. 115, 1893.
Gives analyses of waters from Caledonia and American Carlsbad springs of Caledonia and Nashville, New York, and of a thermal spring near Ojo Caliente, New Mexico (pp. 113–114).

65 —— Analyses of rocks from the laboratory of the United States Geological Survey, 1880–1903.
U. S. Geol. Surv., Bull. no. 228, pp. 375, 1904.
Among analyses are included travertines, tufas, and calcareous and silicious sinters from Yellowstone National Park, by J. E. Whitfield and F. A. Gooch (pp. 298–299, 322–323). Several of the analyses are published for the first time.

66 **Clements** (J. Morgan) and **Smith** (H. L.). Crystal Falls iron-bearing district of Michigan.
U. S. Geol. Surv., 19th Ann. Rept., pt. 3, pp. 19–145, 1898.
Notes the work of infiltrating waters in the deposition of ores of the Mansfield formation (p. 43) and Upper Huronian (p. 80).

67 **Clements** (J. Morgan). The Crystal Falls iron-bearing district of Michigan: The western part of the Crystal Falls district.
U. S. Geol. Surv., Mon., vol. 36, pp. 11–322, 1899.
In the discussion of the ores of the Mansfield slate the drowning of the Mansfield mine by a caving of the roof, allowing the river to enter, is mentioned (pp. 65–66). The ores are regarded in part as replacement deposits, due to alteration by downward infiltrating waters (p. 76, etc.). The ores of the Upper Huronian are regarded as concentrations in a synclinal trough (pp. 183–184).

68 **Clements** (J. Morgan), **Leith** (C. K.), **Van Hise** (C. R.) and. Iron-ore deposits of Lake Superior region.

See Leith (C. K.) and Clements (J. Morgan) and Van Hise (C. R.).

69 —— The Vermilion iron-bearing district of Minnesota, with an atlas.

U. S. Geol. Surv., Mon., vol. 45, pp. 463, atlas, 1903.

The ores of the Soudan formation are ascribed to replacement of cherty carbonates in sedimentary rocks, including jaspellites, by downward percolating waters (pp. 227–234). Underground circulation and processes of replacement are considered (pp. 228–230). Explanations similar to those of the Soudan ores are applied to those of the Agawa formation (p. 329).

70 **Collier** (Arthur J.). A reconnaissance of the northwestern portion of Seward Peninsula, Alaska.

U. S. Geol. Surv., Prof. Paper no. 2, pp. 70, 1902.

Describes the boiling sulphur springs along Spring Creek in the Shishmaref region. They are surrounded by a mound of deposits 10 feet wide and 2 feet high (p. 56).

71 **Cooper** (W. F.). Lower Michigan. [Well and spring records.]

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 102, pp. 489–512, 1904.

Considers briefly the general underground water conditions (p. 489), and gives tables and notes on wells (pp. 490–506) and springs (pp. 507–512). The well data includes depth, head, source, temperature, yield, quality (with analyses), uses, and records; the spring data, temperature, quality (with analyses), yield, source, uses, and improvements.

72 **Cowgill** (Elias Branson). Irrigation practice on the Great Plains.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 5, pp. 39, 1897.

Among other methods the paper considers pumping for irrigation purposes (p. 14).

73 **Crosby** (William O.) and **La Forge** (Laurence). Massachusetts. [Well and spring records.]

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 102, pp. 94–111, 1904.

Considers briefly the general underground water conditions (pp. 94–95) and gives tables and notes relating to wells (pp. 96–102) and springs (pp. 102–111). The well data includes source, yield, quality, temperature, uses, records, and analyses; the spring data, temperature, quality, yield, source, uses, and analyses.

74 **Crosby** (William O.). Rhode Island. [Well and spring records.]

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 102, pp. 119–125, 1904.

Gives well tables showing diameter, depth, source, temperature, yield, quality, uses, analyses, etc., and spring tables giving temperature, quality, yield, source, analyses, and uses.

75 **Cross** (Whitman). Geology of the Rico Mountains, Colorado: Outline of the geology.

U. S. Geol. Surv., 21st Ann. Rept., pt. 2, pp. 17–36, 1900. Landslides, ibid., pp. 129–151.

Describes the occurrence of springs charged with H_2S, CO_2, and $CaCO_3$, which are perhaps remnants of solfataric action (p. 33). Describes the work of underground waters in assisting landslides.

76 **Curtis** (Joseph Story). Silver-lead deposits of Eureka, Nevada.

U. S. Geol. Surv., Mon., vol. 7, pp. 200, 1884.

Gives a chapter on the water in mines, discussing its relation to fissures and types of rock (pp. 107–110). Notes the influence of water level on oxidation (p. 51). Mentions ore deposits of caves in Missouri and upper Mississippi Valley (pp. 65–66), and ascribes the chamber deposits of Eureka to ascending underground waters (pp. 71–74).

D.

77 **Dall** (William Healey), and **Harris** (Gilbert Dennison). Correlation papers. Neocene.

U. S. Geol. Surv., Bull. no. 84, pp. 349, 1892.

A number of well sections are given in connection with descriptions of rocks of New Jersey (pp. 41–44), Delaware (p. 46), and Florida (pp. 103, 108–109). The natural wells of North Carolina (p. 72), and the circulation of water, including underground streams in Florida, is considered, and sinks and other topographic features resulting from solution mentioned. Some of the Florida springs are described (pp. 88–95).

78 **Darton** (Nelson Horatio). Bibliography of North American geology for 1886.

U. S. Geol. Surv., Bull. no. 44, pp. 35, 1887.

Several water papers are listed under author's name, but are not indexed by subjects.

79 —— Record of North American Geology for 1887 to 1889, inclusive.

U. S. Geol. Surv., Bull. no. 75, pp. 173, 1891.

Water papers listed in general only under authors.

80 —— Record of North American Geology for 1890.

U. S. Geol. Surv., Bull. no. 91, pp. 88, 1891.

Water papers are not listed except under authors.

81 —— Record of North American Geology for 1891.

U. S. Geol. Surv., Bull. no. 99, pp. 73, 1892.

Papers relating to water are listed only under authors' names.

82 —— Fredericksburg folio, Virginia-Maryland.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 13, pp. 6, 1894.

Describes the underground waters at the base of the Columbia and Lafayette formations and the artesian waters of the sandy horizons of the Potomac and Pamunkey. The areas of probable flowing waters are defined (p. 6).

83 —— Administrative report.

U. S. Geol. Surv., 15th Ann. Rept., pp. 153–155, 1895.

Describes work relating to artesian waters (p. 155).

84 **Darton** (Nelson Horatio.) Preliminary report on artesian waters of a portion of the Dakotas.

U. S. Geol. Surv., 17th Ann. Rept., pt. 2, pp. 603, 1896.

The paper gives an outline of the geologic conditions (pp. 610–612) and describes the various water horizons (pp. 612–614) and their extent (pp. 614–617), after which the descriptions of the wells and of the well prospects in the Dakotas are taken up by counties (pp. 617–665). The pressure and head (pp. 665–670), composition (pp. 676–679), origin (pp. 679–680), and amount (pp. 680–681) of the waters, together with their use for irrigation (pp. 681–690) and power (pp. 690–691) are considered. The problems of construction and management are also treated. Numerous sections and other illustrations are given.

85 —— Catalogue and index to contributions to North American geology, 1732–1891.

U. S. Geol. Surv., Bull. no. 127, pp. 1045, 1896.

Artesian waters and springs are not indexed as such, but a few reference occur under geologic philosophy, miscellaneous, and under geologic philosophy, chemic geology.

86 —— Artesian well prospects in the Atlantic Coastal Plain region.

U. S. Geol. Surv., Bull. no. 138, pp. 232, 1896.

Discusses the geologic structure and artesian conditions (pp. 18–22) and describes the water horizons, wells, structure, conditions, prospects, composition of waters, etc., for each of the States from New York to Georgia. Among the water-bearing formations considered are the Crystalline rocks, Potomac, Matawan, Middle Marl (Rancocas) Miocene, Pamunkey, Redbank, Chesapeake, Columbia, etc.

87 —— Nomini folio, Maryland-Virginia.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 23, pp. 4, 1896.

Describes springs and shallow and artesian wells. Flowing water comes from the Chesapeake formation, but occurs only in the lowlands, pumping being resorted to in the uplands. The shallow waters are from the base of the Columbia or Lafayette. Gives a map showing the areas of flowing wells and the depths to the basal sands of the Chesapeake, and the sands within and at the base of the Pamunkey (p. 4).

88 —— Franklin folio, West Virginia-Virginia.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 32, pp. 6, 1896.

Notes the occurrence of sinks in the Shenandoah and caverns in the Lewistown limestone (pp. 2–3).

89 —— New developments in well boring and irrigation in eastern South Dakota, 1896.

U. S. Geol. Surv., 18th Ann. Rept., pt. 4, pp. 561–615, 1897.

Gives progress of well sinking by counties (pp. 568–590) and shows view of lake supplied by artesian water (pl. 39). Area of known artesian water has been extended up the Missouri Valley above Pierre and probably to Bismarck, up the Big Cheyenne to the Black Hills, and up Moreau River and elsewhere. Many heavy pressures have been encountered (pp. 590–592). Other points considered or illustrated are depth to bed rock, use of well water for irrigation, temperature of well waters, chemical analyses of wells and springs, and volume (pp. 592–615).

90 **Darton** (Nelson Horatio). Preliminary report on the geology and water resources of Nebraska west of the one hundred and third meridian.

U. S. Geol. Surv., 19th Ann. Rept., pt. 4, pp. 719–785, 1898.

Discusses topography and geology (pp. 727–760), underground waters (pp. 761–766), springs (pp. 766–768), and windmill irrigation from wells (p. 780). The following water horizons are considered: Alluvium, Pierre, Ogallala, Arikaree, Gering, Brule, Chadron, Laramie, and Dakota formations, and the Carboniferous limestones. Many illustrations and two underground water maps are given.

91 —— Underground waters of a portion of southeastern Nebraska.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 12, pp. 56, 1898.

Describes the topography (pp. 12–14) and the geology (pp. 14–24) of the region and considers the shallow water-bearing horizons (largely under 150 feet in depth) in fifteen counties (pp. 24–45). Of the deep borings, from 590 to 2,460 feet, only one appears to have reached the Dakota sandstone, and this was a failure. Although drilling through the Cretaceous would be expensive, Dakota water could probably be obtained at many points (pp. 47–48). The use of underground waters for irrigation is described for seven counties.

92 —— Monterey folio, Virginia-West Virginia.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 61, pp. 7, 1899.

Notes the occurrence of thermal springs, sinks, and caves in the Shenandoah limestone (p. 2).

93 —— Preliminary description of the geology and water resources of the southern half of the Black Hills and adjoining regions of South Dakota and Wyoming.

U. S. Geol. Surv., 21st Ann. Rept., pt. 4, pp. 489–599, 1900.

Discusses the topography and geology (pp. 498–562) and considers the waters of the Dakota-Lakota, Minnelusa, and Deadwood sandstones, including wells and springs (pp. 563–574).

94 —— Washington folio, District of Columbia-Maryland-Virginia. Underground water.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 70, pp. 7, 1901.

Describes the sources of water supplies, including the crystalline rocks, and the Potomac, Columbia, and other sedimentary beds. A map showing depths to the top and base of the Potomac formation is given.

95 —— Preliminary list of deep borings in the United States. Part 1 (Alabama-Montana).

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 57, pp. 60, 1902.

Consists of tables giving town, county, depth, diameter, yield, head, temperature, quality, etc., of wells over 400 feet alphabetically arranged by States from Alabama to Montana. References to published records are given.

96 **Darton** (Nelson Horatio). Preliminary list of deep borings in the United States. Part 2 (Nebraska-Wyoming).

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 61, pp. 67, 1902.

Contains well statistics alphabetically arranged by States from Nebraska to Wyoming.

97 —— Norfolk folio, Virginia-North Carolina.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 80, pp. 4, 1902.

Gives a number of shallow well sections in the text and columnar sections of the deep wells at Norfolk and Fort Monroe on the Well Section Sheet. Most of the well supplies are from the base of the Columbia, the deep wells reaching into the Potomac generally obtaining salt water. Several analyses are given. The results of the deep wells at Norfolk, Fort Monroe, Newport News, and Virginia Beach are discussed.

98 —— Oelrichs folio, South Dakota-Nebraska.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 85, pp. 6, 1902.

Describes the thermal springs of the Minnekahta limestone (p. 3), and gives a map showing the outcrop of the Dakota sandstone, the areas of flowing and pump wells, the depth to the top of the Dakota sandstone, and the altitude to which the water will rise (pp. 5–6).

99 —— Preliminary report on the geology any water resources of Nebraska west of the one hundred and third meridian.

U. S. Geol. Surv., Prof. Paper no. 17, pp. 69, 1903.

Revised edition of no. 90.

100 —— Camp Clarke folio, Nebraska.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 87, pp. 4, 1903.

Describes the character and volume of springs and notes the sinking into the ground of the waters (p. 1). The shallow waters of the river bottoms and the waters of the Arikaree and Ogallala formations are considered. On the table-land abundant and good water can be obtained at depths of from 200 to 300 feet. The Dakota sandstone is untested, but is probably within reach of the drill and will yield good and abundant flows (p. 6).

101 —— Scotts Bluff folio, Nebraska.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 88, pp. 5, 1903.

Notes the occurrence of spring and seepage water in the valley of Pumpkin Creek (p. 1) and describes the underground waters of the alluvium, etc., along the North Platte (p. 5). The presence of shallow water on the uplands is uncertain, as is also the case in the Brule clay, because of its fissures and crevices. The Laramie is regarded as a possible source of water. The Dakota is untested, but could probably be reached at 2,000 feet or more and be likely to furnish good flows. The Arikaree formations furnishes water on the plateau at a depth of 200 feet and outcrops with springs in the canyons (p. 5).

102 —— Newcastle folio, Wyoming-South Dakota.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 107, pp. 9, 1904.

Gives a number of well records (pp. 3–5, 8) and discusses at length the underground waters of the Dakota, Lakota, and Pahasapa horizons (pp. 8–9). An analysis of Dakota water is given (p. 8). The artesian water map shows the depths of the Dakota and Pahasapa standstones and the areas of flowing and pump wells. The finding of brines is recorded and an analysis given (p. 9).

103 **Darton** (Nelson Horatio) and (**Smith**) W. S. Tangier. Edgemont folio, South Dakota-Nebraska.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 108, pp. 10, 1904.

Describes the occurrence of sinks and caves in the Minnekahta limestone (p. 3) and of recent calcareous tufa deposits (p. 7). The occurrence of underground waters from the Dakota and Lakota sandstones, together with records and analyses, are discussed (p. 9) and a map showing the areas of flowing and pump wells and the depth and head of the water is given.

104 **Darton** (Nelson Horatio). Western hydrology.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 93, pp. 117–120, 1904.

Tells of the formation and scope of the western section, division of hydrology, and describes the work in Arizona, California, Colorado, Kansas, Nebraska, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Washington, and Wyoming. The work of the following men is considered: W. T. Lee, W. C. Mendenhall, C. E. Siebenthal, G. E. Condra, E. H. Barbour, C. R. Keyes, C. N. Gould, D. E. Willard, C. M. Hall, F. A. Wilder, I. C. Russell, J. E. Todd, G. B. Richardson, Henry Landes, C. A. Fisher, and C. C. O'Harra.

105 **Davis** (Arthur Powell). Report of progress of stream measurements for the calendar year 1896.

U. S. Geol. Surv., 18th Ann. Rept., pt. 4, pp. 1–418, 1897.

Notes the decrease in flow of wells and springs in Georgia (p. 71) and describes the limestone springs along the Etowah River, Georgia (p. 109). Seepage into lava from Malad River, Idaho (p. 337), and the springs and underflow along Little Fountain Creek, California (p. 231), are also considered.

106 —— Irrigation near Phoenix, Arizona.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 2, p. 98, 1897.

Discusses underground waters briefly (pp. 86–92), naming Phoenix and Mesa as examples of localities having large flows due in part to additions received by the underground supplies through seepage from irrigated tracts. Gives a list of wells of Pinal and Maricopa counties, together with statistics; considers the amount of underflow to be overestimated, the effect of evaporation underestimated; discusses the cost of pumping.

107 —— Investigations in Arizona.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 93, pp. 128–130, 1904.

Irrigation of 50,000 acres by wells is expected (p. 128).

108 **Day** (David T.). Bromine.

U. S. Geol. Surv., Min. Res., 1883–84, pp. 851–853, 1885.

Notes the brines of the wells of West Virginia and Ohio as sources of bromine.

109 —— Iodine.

U. S. Geol. Surv., Min. Res., 1883–84, pp. 854–858, 1885.

Like bromine, iodine is devived from the waters of salt wells.

110 **Day** (David T.). Sulphur.
U. S. Geol. Surv., Min. Res., 1883–84, pp. 864–876, 1885.
Notes the derivation of sulphur from hot spring deposits in Nevada and from solfataras in Utah (pp. 865–866).

111 —— Bromine.
U. S. Geol. Surv., Min. Res., 1885, pp. 486–487, 1886.
Notes the extraction of bromine from the brines of the salt wells.

112 [——] Salt.
U. S. Geol. Surv., Min. Res., 1885, pp. 474–485, 1886.
Discusses the brines from wells or springs of Michigan, New York, California, Nevada, and Idaho.

113 —— Administrative report [1886–87].
U. S. Geol. Surv., 8th Ann. Rept., pt. 1, pp. 195–201, 1889.
Reports 8,950,317 gallons of mineral water, with a value of $1,284,070, sold during 1886. This is a slight increase over the previous year.

114 —— Administrative report [1887–88].
U. S. Geol. Surv., 9th Ann. Rept., pp. 134–140, 1889.
The production of mineral waters for 1887 is stated as 8,259,609 gallons, with a value of $1,261,473.

115 —— Administrative report [1888–89].
U, S. Geol. Surv., 10th Ann. Rept., pt. 1, pp. 182–188, 1890.
The product of mineral waters for 1888 is given as 9,628,568 gallons, valued at $1,709,302, an increase in both amount and value.

116 —— Administrative report [1890–91].
U. S. Geol. Surv., 12th Ann. Rept., pt. 1, pp. 129–134, 1891.
Gives the production of mineral waters for 1890 as 14,000,000 gallons, valued at $2,000,000.

117 [——] Salt [1891].
U. S. Geol. Surv., Min. Res. of U. S. 1891, pp. 572–578, 1893.
Gives production of salt from wells, springs, and other sources for the year 1891.

118 [——] Bromine [1891].
U. S. Geol. Surv., Min. Res. of U. S. 1891, p. 579, 1893.
Gives production of bromine as a by-product of brines, etc., for 1891.

119 —— Administrative report [1893–94].
U. S. Geol. Surv., 15th Ann. Rept., pp. 203–209, 1895.
Gives the production of mineral waters for 1893 as 23,544,495 gallons, with a value of $4,246,734 (p. 209).

120 **Day** (William C.). Potassium salts.
U. S. Geol. Surv., Min. Res., 1887, pp. 628–650, 1888.
These salts are obtained in part from the brine of wells and springs. Analyses are given.

121 **Diller** (Joseph Silas). Lassen Peak folio, California.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 15, p. 4, 1895.
Mentions or describes a number of solfataras, hot springs, mud pools, geysers, and sulphur deposits (p. 2).

122 **Diller** (Joseph Silas). Stalactites. The educational series of rock specimens collected and distributed by the United States Geological Survey.
U. S. Geol. Surv., Bull. no. 150, pp. 98–99, 1898.
Explains origin through action of underground waters.

123 **Dodwell** (Arthur) and **Rixon** (Theodore F). Forest conditions in the Cascade Forest Reserve, Oregon: Cascade Range Forest Reserve between townships 18 and 29 south.
U. S. Geol. Surv., Prof. Paper no. 9, pp. 147–227, 1903.
Describes underground channel through which fish pass from Deschutes River to Odell and Davis lakes (p. 148).

124 —— **Leiberg** (John B.), **Rixon** (Theodore), and. Detailed descriptions [of timber of townships]. Forest conditions in the San Francisco Mountains forest reserve, Arizona.
U. S. Geol. Surv., Prof. Paper no. 22, pp. 35–91, 1904.
See Leiberg (John B.), Rixon (Theodore), and Dodwell (Arthur).

125 **Drake** (Noah Field), **Lindgren** (Waldemar), and. Nampa folio, Idaho-Oregon.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 103, pp. 5, 1904.
See Lindgren (Waldemar) and Drake (N. F.).

126 —— Silver City folio, Idaho.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 105, pp. 6, 1904.
See Lindgren (Waldemar) and Drake (N. F.).

127 **Dutton** (Clarence E.). The physical geography of the Grand Canyon district.
U. S. Geol. Surv., 2d Ann. Rept., pp. 47–166, 1882.
Notes several springs available for camp supplies in the Kaibab and other parts of the plateau district, and mentions the occurrence of sinking streams (pp. 122, 134).

128 —— Tertiary history of the Grand Canyon district, with atlas.
U. S. Geol. Surv., Mon., vol. 2, 264 pp., atlas, 1882.
Springs in canyons are mentioned or described on pages 130, 135, 158, 159, and 168; on the Kaibab on pages 129, 139, 157, 166, 171, 172, on the Uinkaret, page 82. Springs are also treated on pages 158, 159, 168, and 234. Sinking streams are considered on pages 129 and 138, and subterranean drainage on page 138.

129 —— Administrative report. [1886–87.]
U. S. Geol. Surv., 8th Ann. Rept., pt. 1, pp. 156–165, 1889.
Mentions two immense springs giving rise to Metolias River, on east flank of cascades, which is 70 to 80 feet wide and too deep to ford. Other large springs are noted.

130 **Dutton** (Clarence E.). The earthquake at Charleston of August 31, 1886.

U. S. Geol. Surv., 9th Ann. Rept., pp. 203–328, 1889.

Notes the forcing up of fresh water and mud, the formation of mud craterlets, sink holes, etc. (pp. 224, 241, 246, 280–281, 283, 296, 297, 298, 302, 322). Mention is made of the failure of artesian wells at Ten Mile Hill, Georgia (p. 284), and of rise of water in certain wells in Alabama (p. 411). The supposed effect on Iowa wells is discredited (p. 443).

E.

131 **Eckel** (Edwin C.). Salt and gypsum deposits of southwestern Virginia.

U. S. Geol. Surv., Bull. no. 213, pp. 406–416, 1903.

Describes salt wells (pp. 407, 408, 413) and gives records (pp. 408–409). Analyses of brines from Virginia, New York, Ontario, Michigan, Pennsylvania, West Virginia, England, and France are also given (p. 414).

132 —— **Hayes** (C. Willard) and. Iron ores of the Cartersville district, Georgia.

See Hayes (C. W.) and Eckel (E. C.).

133 —— **Hayes** (C. W.) and. Occurrence and development of ochei deposits in the Cartersville district, Georgia.

See Hayes (C. W.) and Eckel (E. C.).

134 **Eckel** (Edwin C.). The salt industry in Utah and California.

U. S. Geol. Surv., Bull. no. 225, pp. 488–495, 1904.

Notes the derivation of salt from springs in California (p. 494).

135 —— **Johnson** (Lawrence C.) and, Mississippi. [Well records.]

U. S. Geol. Surv., Water Supply and Irrigation Paper no. 102, pp. 332–357, 1904.

See Johnson (Lawrence C.) and Eckel (Edwin C.).

136 **Eldridge** (George Homans). A geological reconnoissance in northwest Wyoming.

U. S. Geol. Surv., Bull. no. 119, pp. 72, 1894.

The paper describes the Stinking Water, Big Horn, and Fort Washakie Sulphur Springs. All are hot or warm, have copious flows, and are surrounded by mineral deposits, the first by a geyser cone. The waters are considered to possess valuable medicinal properties. The Big Horn and Fort Washakie springs occur at the crest of anticlines.

137 —— Anthracite-Crested Butte folio. Description of the sedimentary formations.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 9, pp. 6–10, 1894.

Describes hot springs and calcareous tufa mounds along Ament Creek (p. 9).

138 **Eldridge** (George Homans). Geology of the Denver Basin in Colorado: Economic geology, artesian wells.

U. S. Geol. Surv., Mon., vol. 27, pp. 401–465, 1896.

The chapter includes a history of the development of the basin, and discussions of the artesian conditions, water horizons, source of water, absorption, transmission, capacity, and yield of water horizons, and life of wells. Chemical analyses, sections, and descriptions of wells are given, together with statistics of location, date, casing, water horizon, depth, discharge in 1886 and 1890, cost, etc., for 357 wells.

139 **Emerson** (Benjamin Kendall). Geology of old Hampshire County, Massachusetts, comprising Franklin, Hampshire, and Hampden counties.

U. S. Geol. Surv., Mon., vol. 29, pp. 790, 1898.

Gives a number of deep-well records in Triassic rocks (pp. 380–389), but little information relating to water. Springs are described and analyses given (pp. 751–752).

140 —— The geology of eastern Berkshire County, Massachusetts.

U. S. Geol. Surv., Bull. no. 159, pp. 139, 1899.

Describes the wells on the Dalton fault, giving record, map, and analysis. The water comes from solution passages in the limestone along the fault (pp. 90–92).

141 **Emmons** (Samuel Franklin). Geology and mining industry of Leadville, Colorado, with atlas.

U. S. Geol. Surv., Mon., vol. 12, pp. 770, atlas, 1886.

Among the topics relating to underground waters, the following may be noted: Caves in limestone (p. 394), warm springs (p. 169), and water level in mines (p. 378). Ores are regarded as having been deposited by descending aqueous solutions following natural water channels including bedding planes, joints, and cleavage (p. 378). The thermal spring origin of fissure veins is also mentioned on page 576.

142 —— Anthracite-Crested Butte folio. Description of the Elk Mountains.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 9, pp. 1–2, 1894.

Mentions the travertine and tufa deposits of hot springs and describes the formation of bog ore by the leaching of sulphurets by thermal waters (p. 2).

143 —— Introduction. Economic geology of the Mercur mining district, Utah. By J. Edward Spurr.

U. S. Geol. Surv., 16 Ann. Rept., pt. 2, pp. 349–369, 1896.

Considers the part of hot underground waters in ore deposition (pp. 367–369).

144 —— Mines of Custer County, Colorado.

U. S. Geol. Surv., 17th Ann. Rept., pt. ii, pp. 465–472, 1896.

Ascribes ores of Bull Domingo and Geyser mines to aqueous deposition (pp. 445–447, 458–464). The latter mine is characterized by strong flows of water charged with carbonates, sulphates, nitrates, etc., of the alkalies, alkaline earths, and metals. Analyses of the water and of the tufaceous deposits formed by it on its emergence are given.

145 **Emmons** (Samuel Franklin) and **Tower** (George Warren). Butte Special folio, Montana.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 39, pp. 8, 1897.

Notes the action of thermal waters on andesites (p. 6) and describes the superficial and deep-seated springs of the area. The former are generally located at the base of prominences of porous igneous rocks, and are numerous and copious in flow. The latter are both cold and warm, and are generally more or less mineralized, some being used for medicinal purposes. Alkaline carbonates, carbon dioxide, and sulphuretted hydrogen are common constituents. Some mineral deposits occur (p. 8).

146 **Emmons** (Samuel Franklin). Tintic Special folio, Utah. General conclusions.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 65, pp. 7–8, 1900.

Discusses the significance of the ground-water level and describes certain cave deposits.

147 —— Homestake mines.

U. S. Geol. Surv., Prof. Paper no. 26, pp. 55–80, 1904.

Notes relation of underground waters to ore deposition.

F.

148 **Fairbanks** (H. A.). San Luis folio, California.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 101, pp. 14, 1904.

Describes a number of strong iron and other springs, some of which are used for bathing (pp. 14).

149 **Fellows** (A. L.). Water resources of the State of Colorado.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 74, pp. 151, 1902.

Notes the absorption of rainfall by different varieties of rocks (p. 17) and describes seepage of the South Platte (pp. 65–66), Arkansas River (p. 100), and the Rio Grande (pp. 109–110).

150 **Fenneman** (N. M.). The Boulder, Colorado, oil field.

U. S. Geol. Surv., Bull. no. 213, pp. 322–332, 1903.

Discusses the occurrence of fresh and salt water in oil wells, some of which are cased to over 2,000 feet. The lower waters are thermal and rise with some force.

151 **Field** (John E.). Diversion of North Platte River [Wyoming-Nebraska].

U. S. Geol. Surv., 2d Ann. Rept. Reclamation Service, 1902–3, pp. 499–507, 1904.

Notes occurrence of hot springs, and describes honeycombing of rock by their agency at Alcova, Wyo. (p. 506).

152 **Flynn** (Benjamin H.), and **Flynn** (Margaret S.). The natural features and economic development of the Sandusky, Maumee, Muskingum, and Miami drainage areas in Ohio.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 91, pp. 130, 1904.

Discusses public water supplies, including those from springs, galleries and from shallow and deep-seated wells, both flowing and nonflowing (pp. 58–124).

153 **Foerste** (Aug. F.). Geology of the Carboniferous strata of the southwestern portion of the Narragansett basin, with an account of the Cambrian deposits.
U. S. Geol. Surv., Mon., vol. 33, pp. 214–393, 1899.
Gives record of deep boring in Rhode Island (p. 322).

154 **Fontaine** (William Morris). The Potomac formation in Virginia.
U. S. Geol. Surv., Bull. no. 145, pp. 149, 1896.
Gives an artesian-well section at Fort Monroe (p. 44) and describes an alum spring near Fredericksburg (p. 68).

155 **Fortier** (Samuel). Seepage water of northern Utah.
U. S. Geol. Surv., Water Supply and Irrigation Paper no. 7, pp. 50, 1897.
Defines seepage waters (p. 11) and considers their importance (pp. 11–13) and origin (p. 13). A considerable number of measurements showing quantity of seepage water in Cache Valley (pp. 27–44) and in Ogden Valley (pp. 44–47) are given. In the lower portion of the latter more water is returned by seepage than taken out for irrigation during certain months.

156 —— Conveyance of water in irrigation canals, flumes, and pipes.
U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 43, pp. 86, 1901.
Notes the effect of irrigation in raising the groundwater level (p. 16).

157 [**Fuller** (Myron L.)], **Campbell** (Marius R.) [and]. Masontown-Uniontown folio, Pennsylvania natural gas; Petroleum.
See Campbell (Marius R.) and [Fuller (Myron L.)].

158 **Fuller** (Myron L.). Ditney folio, Indiana: General and Pleistocene geology.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 83, pp. 1–7, 1902.
Gives diamond drill section near Glezen post-office (p. 2) and a number of scattered drift well sections (p. 3).

159 —— Ditney folio, Indiana. Mineral waters: Water supply.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 84, p. 8, 1902.
Describes the character and composition of the mineral springs at the Degonia and Ash Iron Spring resorts, and mentions the occurrence and deposits of Chalybeate Springs. The amount and character of the water supply from drift and rocks is also discussed.

160 —— Gaines folio, Pennsylvania. General geology.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 92, pp. 9, 1903.
Gives deep well record at Gaines (p. 2) and describes a 2,880-barrel water well from a depth of 100 feet in the Chemung rocks at Harrison Valley. The water is mineralized and is regarded of medicinal value (p. 9).

161 —— Natural gas [Brownsville-Connellsville folio].
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 94, pp. 17–18, 1903.
Gives detailed records of several deep wells.

162 **Fuller** (Myron L.) and **Clapp** (Frederick G.). Patoka folio, Indiana-Illinois.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 105, 12 pp., 1904.

Gives a number of well records (p. 3) and discusses the occurrence of groundwater, including that of springs and wells, in considerable detail (pp. 11–12). The occurrence of calcareous tufa is described (p. 14).

163 **Fuller** (Myron L.). Hyner gas pool, Clinton County, Pennsylvania.

U. S. Geol. Surv., Bull. no. 225, pp. 392–395, 1904.

Gives record of 1,965-foot well and notes occurrence of fresh and salt waters at various horizons.

164 —— Water supply from wells in southern Louisiana.

U. S. Geol. Surv., Water Supply and Irrigation Paper no. 101, pp. 74–81, 1904.

Discusses the use of well water for domestic, town, railroad, and manufacturing supplies, giving a list of towns supplied from wells and a table of analyses. The subject of contamination is also discussed.

165 —— Rice irrigation in southern Louisiana.

U. S. Geol. Surv., Water Supply and Irrigation Paper no. 101, pp. 82–94, 1904.

Deals mainly with irrigation by water obtained from wells, giving tables showing number of farms and acres irrigated by such waters in 1902 (pp. 82–91). A map showing wells and canals is included.

166 —— Introduction: Contributions to the hydrology of Eastern United States, 1903.

U. S. Geol. Surv., Water Supply and Irrigation Paper no. 102, pp. 9–13, 1904.

States object of progress reports, gives list of publications of the Survey and a bibliography of principal Survey publications relating to underground waters.

167 —— Organization of the division of hydrology and work of the eastern section.

U. S. Geol. Surv., Water Supply and Irrigation Paper no. 102, pp. 15–20, 1904.

Gives an account of early Survey work on underground waters, of the organization and scope of the division of hydrology, and a description of the work by States as follows: Maine, W. S. Bayley, G. O. Smith, W. C. Washburn, and L. G. Lord; New Hampshire, J. M. Boutwell; Vermont, G. H. Perkins; Massachusetts and Rhode Island, W. O. Crosby; Connecticut, H. E. Gregory; New York, A. C. Veatch, Arthur Hollick, M. L. Fuller, C. S. Slichter, W. O. Crosby, and F. B. Weeks; New Jersey, G. N. Knapp; Georgia, S. W. McCallie; Florida, M. L. Fuller; Minnesota, C. W. Hall; Wisconsin, A. R. Shultz; Michigan, W. F. Cooper; Iowa, W. H. Norton; Missouri, E. M. Shepard; Arkansas, A. C. Veatch and A. H. Purdue; Louisiana, A. C. Veatch and G. D. Harris; Kentucky and Tennessee, L. C. Glenn; Alabama and Mississippi, E. A. Smith, L. C. Johnson, J. A. Anderson, R. S. Hodges, and B. F. Lovelace.

168 **Fuller** (Myron L.). Introduction. Notes on the wells, springs and general water resources of certain Eastern and Central States.

U. S. Geol. Surv., Water Supply and Irrigation Paper no. 102, pp. 21–26, 1904.

Discusses the methods of work, including the collection, preparation, and presentation of data, the economic value of general water resources, well and spring records, analyses, etc., and gives an explanation of the tables of the report.

169 —— Florida. [Well and spring records.]

U. S. Geol. Surv., Water Supply and Irrigation Paper no. 102, pp. 238–274, 1904.

Discusses the general underground water conditions (pp. 238–239) and gives tables and notes relating to wells (pp. 240–264) and springs (pp. 265–274). The well data include altitude, depth, source, head, temperature, quality (including analyses), records, and uses; the spring data, temperature, quality (including analyses), source, uses, improvements, etc.

G.

170 **Gilbert** (Grove Karl). Lake Bonneville.

U. S. Geol. Surv., Mon. vol. 1, 438 pp., 1890.

Mentions springs in Death Valley, California (p. 8), and elsewhere (p. 102), Ice spring, Utah (p. 325), hot springs of Fumerole Butte, Utah (p. 333), of Salt Lake City (p. 349), and of Bonneville village, Utah (p. 350), the last two being on faults, are also considered. Other hot springs are noted.

171 —— Administrative report [1890–91].

U. S. Geol. Surv., 12th Ann. Rept., pt. 1, pp. 52–65, 1891.

Discusses underground temperatures as based on observations in the 4,471-foot well at Wheeling, West Virginia.

172 —— Administrative report [1891–92].

U. S. Geol. Surv., 13th Ann. Rept., pt. 1, pp. 83–98, 1892.

Notes work of A. C. Peale on mineral waters (p. 88) and of William Hallock on temperatures of Wheeling deep well (p. 96).

173 —— Administrative report.

U. S. Geol. Surv., 15th Ann. Rept., pp. 144–148, 1895.

Gives an account of studies on the artesian conditions and of the contouring of the Dakota sandstone in southern Colorado, etc. (pp. 145–146).

174 —— The underground water of the Arkansas Valley in eastern Colorado.

U. S. Geol. Surv., 17th Ann. Rept., pt. 2, pp. 551–601, 1896.

Describes the geology of the region (pp. 560–580) and considers the derivation of underground waters (pp. 557–558) and general artesian conditions (p. 581). The character, catchment area, capacity, distribution, quality, analyses, and prospects of the Dakota sandstone or its waters are treated at length (pp. 582–595), while the ground water in gravels, in upland and dune sands, and in the terraces is discussed (pp. 595–598). The considerable underflow of the Arkansas and other streams is pointed out (pp. 599–601).

175 **Gilbert** (Grove Karl). Pueblo folio, Colorado.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 36, pp. 7, 1897.

Notes the loss of water through absorption by the beds of the Arkansas and St. Charles rivers (p. 1) and discusses the various water horizons in the Dakota sandstone, including their depth and head. A map showing the areas of flowing and nonflowing wells and the depths of the water horizons is given.

176 **Glenn** (L. C.). Tennessee. [Well records.]

U. S. Geol. Surv., Water Supply and Irrigation Paper no. 102, pp. 358–367, 1904.

Gives a general statement of underground water conditions (pp. 358–359) and presents tables and notes relating to wells (pp. 360–365). These include data bearing on depth, head, source, yield, quality, records, and uses.

177 —— Kentucky. [Well records.]

U. S. Geol. Surv., Water Supply and Irrigation Paper no. 102, pp. 369–373, 1904.

Considers briefly the general underground water conditions and gives tables and notes relating to wells. These include statistics on depth, head, yield, quality (including analysis), records, and uses.

178 **Gooch** (Frank Austin) and **Whitfield** (James Edward). Analyses of waters of the Yellowstone National Park with an account of the methods of analyses employed.

U. S. Geol. Surv., Bull. no. 47, pp. 84, 1888.

Gives the temperatures, specific gravities, and analyses of 43 waters including those from geysers, hot springs, cold springs, mud springs, etc. Among the rare compounds or elements of waters which were found are B_2O_3, As_2O_3, Br, Mn, Cs, and Rh. N_2O_5, TiO_2, I, Fl, Ba, and Sr were tested for but not found.

179 **Goodell** (Edwin B.). A review of the laws forbidding pollution of inland waters in the United States.

U. S. Geol. Surv., Water Supply and Irrigation Paper no. 103, pp. 120, 1904.

Gives an abstract of laws relating to pollution of surface streams. Springs are specifically included with the streams in nearly all States and wells are included in many instances. Several States have special laws relating to springs.

180 **Gowsell** (M. G.), **Plummer** (Fred G.) and. Forest conditions in the Lincoln Forest Reserve, New Mexico.

U. S. Geol. Surv., Prof. Paper no. 33, pp. 47, 1904.

See Plummer (Fred G.) and Gowsell (M. G.).

181 **Grant** (C. L.). Additional well records in Connecticut.

U. S. Geol. Surv., Water Supply and Irrigation Paper no. 102, pp. 160–165, 1904.

Gives tables showing depth and yield of wells at a considerable number of scattered localities.

182 **Graves** (Henry S.). Black Hills Forest Reserve.

U. S. Geol., Surv., 19th Ann. Rept. pt. 5, pp. 67–164, 1898.

Mentions underground-stream channels in Bear Lodge Range (p. 163).

183 **Gregory** (Herbert E). Connecticut. [Well and spring records.]
U. S. Geol. Surv., Water Supply and Irrigation Paper no. 102, pp. 127-159, 1904.
Considers briefly the general underground water conditions (p. 127), and gives tables and notes relating to wells (pp. 128–149) and springs (pp. 149–159). The well data include source, temperature, yield, quality (including analyses), and uses; the spring data, temperature, yield, source, use, improvements, and quality (including analyses).

184 **Grimsley** (G. P.). Gypsum deposits in Kansas.
U. S. Geol. Surv., Bull. no. 223, pp. 53–59, 1904.
Notes springs associated with gypsite (p. 57) and mentions the action of underground waters in the formation of gypsum (p. 58).

185 **Griswold** (W. T.). The Berea Grit Oil Sand in the Cadiz quadrangle. Ohio.
U. S. Geol. Surv., Bull. no. 198, pp. 43, 1902.
Discusses the relation of water to the accumulation of oil and gas, and gives a map and tables of the wells.

186 —— Structural work during 1901 and 1902 in the Eastern Ohio oil fields.
U. S. Geol. Surv., Bull. no. 213, pp. 336–344, 1903.
Discusses the relation of water to the occurrence of oil and gas (p. 337).

187 **Grunsky** (Carl Ewald). Irrigation near Bakersfield, California.
U. S. Geol. Surv., Water Supply and Irrigation Paper, no. 17, pp. 96, 1898.
Notes use of ground water for irrigation at Florin (p. 14), and reports successful pumping and the beginning of artesian developments in the San Joaquin Valley (p. 94). Irrigation by causing a general rise of the ground water into the subsoil is described (pp. 33–34).

188 —— Irrigation near Fresno, California.
U. S. Geol. Surv., Water Supply and Irrigation Paper, No. 18, pp. 94, 1898.
Discusses seepage (pp. 74–78) and describes irrigation by raising ground-water level to subsoil (p. 90). The effect of irrigation on ground-water level (p. 79) and the ground-water conditions near the Fresno Canal (p. 75) and along Kings River (pp. 86–87) are also considered.

H.

189 **Hague** (Arnold). Administrative report [1883–84].
U. S. Geol. Surv., 5th Ann. Rept., pp. 15–19, 1885.
Gives a brief summary of the work of W. H. Weed, A. C. Peale, and Wm. Hallock on the character, deposits, and causes of the hot springs and geysers of the Yellowstone National Park, and mentions the work of F. A. Gooch on the chemistry of the waters and their deposits.

190 —— Administrative report [1884–85].
U. S. Geol. Surv., 6th Ann. Rept., pp. 54–59, 1885.
Notes the chemical work of F. A. Gooch on methods and problems relating to the thermal waters of Yellowstone National Park, and mentions work of William Hallock on the physics of geyser action. Calls attention to changes in temperature of springs and to new vents.

191 **Hague** (Arnold). Administrative report [1885–86].
U. S. Geol. Surv., 7th Ann. Rept., pp. 87–91, 1888.
Gives list of basins and springs of the Yellowstone National Park from which waters have been analyzed by F. A. Gooch and J. E. Whitfield.

192 —— Administrative report [1886–87].
U. S. Geol. Surv., 8th Ann. Rept. pt. 1, pp. 149–153, 1889.
Mentions the work of W. H. Weed on geyser action in the Yellowstone National Park and states there is no diminution in the intensity of geyser action or other noticeable changes in the geyser region. Mentions the work of Gooch and Whitfield on the chemistry of the waters and notes the occurrence of arsenic in the waters. This may give to the waters an important medicinal value. The occurrence of scorodite in the siliceous sinter cones is mentioned.

193 —— Administrative report [1887–88].
U. S. Geol. Surv., 9th Ann. Rept. (pp. 91–96), 1889.
Describes the state of activity of the geysers of the Yellowstone National Park and mentions the outbreaks of the Excelsior after a dormant period of six years. Notes the work of W. H. Weed on the study of algeous growths in springs and describes the occurrence of scorodite, the hydrous arsenate of iron.

194 —— Administrative report [1888–89].
U. S. Geol. Surv., 10th Ann. Rept., pt. 1, pp. 132–137, 1890.
States that there has been no marked change in geyser action. Describes the work of W. H. Weed in exploring old and new geyser basins and mentions the discovery of arsenic in their waters. The publications of F. A. Gooch, J. E. Whitfield, and W. H. Weed relating to the waters and deposits of hot springs are noted and attention called to the method of inciting geyser action by "soaping."

195 —— Administrative report [1889–90].
U. S. Geol. Surv., 11th Ann Rept., pt. 1, pp. 83–87, 1891.
Notes works of W. H. Weed on the question of changes of activity of geysers and springs in the Yellowstone National Park.

196. —— Administrative report [1890–91].
U. S. Geol. Surv., 12th Ann. Rept., pt. 1, pp. 92–96, 1891.
Describes the work of W. H. Weed on geysers and hot springs.

197 —— Geology of the Eureka District, Nevada, with an atlas.
U. S. Geol. Surv., Mon., vol. 20, pp. 419, 1892.
Notes occurrence of enlarged fissures and caves antedating ore deposition (p. 308) and assigns ore deposition to ascending solfataric currents (p. 294).

198 —— Administrative report [1892–93].
U. S. Geol. Surv., 14th Ann. Rept., pt. 1, pp. 188–191, 1893.
Describes exhibit of hot-spring deposits at World's Fair at Chicago in 1893 (p. 191).

199 **Hague** (Arnold). Yellowstone National Park folio, General Description.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 30, pp. 1–4, 1896.

Describes the geysers, hot springs, and solfataras, and discusses the antiquity of some of the deposits. Glacial bowlders are found imbedded in travertine. The action of acid thermal waters in the decomposition of rocks and their intimate relation to rhyolite are considered. The spring and geyser waters are of three classes (1) calcareous, forming travertine; (2) siliceous, frequently acid, and carrying alum and iron, and (3) siliceous alkaline, forming geyser cones. The occurrence of iron, manganese, and arsenic in the waters and of realgar, orpiment, and scorodite in the deposits is noted. There are 4,000 thermal springs and 100 geysers in the park.

200 —— [and **Weed** (W. H.)]. Descriptive geology of Huckleberry Mountain and Big Game Ridge: Snake River Hot Springs.

U. S. Geol. Surv., Mon., vol. 32, pt. 2, pp. 177–178, 1899.

These are large calcareous thermal springs, associated with travertine deposits resembling those of Mammoth Hot Springs of Yellowstone National Park and occurring on the banks of Snake River. Their relation to rhyolite and to limestone is considered.

201 **Hague** (Arnold). Absaroka folio, Wyoming.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 52, pp. 6, 1899.

Describes the hot sulphur springs of Stinking Water River (p. 1) and mentions the occurrence of active and extinct thermal springs on west slopes of Saddle Mountain, just inside the limits of the Yellowstone National Park on the west. The occurrence of a solfataric area with whitened and decomposed rocks with sulphur deposits is also noted (p. 6).

202 **Hall** (Benjamin M.). Measurement of springs in Georgia.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 102, pp. 236–237, 1904.

Describes and gives results of measurements of flow of a number of large springs in Georgia.

203 —— Measurement of springs in Florida.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 102, pp. 274–275, 1904.

Gives description and statistics of flow for several of the larger springs in Florida.

204 —— Water powers of Alabama, with an appendix on stream measurements in Mississippi.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 107, 253 pp., 1904.

Gives measurements of springs in Cahaba (p. 129) and Tennessee (p. 207) valleys.

205 **Hall** (C. M.), **Todd** (James E.) and. Alexandria folio, South Dakota.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 100, pp. 6, 1903.

See Todd (J. E.) and Hall (C. M.).

206 —— Geology and water resources of part of the lower James River valley, South Dakota.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 90, 47 pp., 1904.

See Todd (James E.) and Hall (C. M.).

207 **Hall** (Christopher W.). Minnesota. [Well and spring records.]

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 102, pp. 441–488, 1904.

Discusses the general underground water conditions (pp. 441–443) and gives tables or notes of shallow wells (pp. 444–469), deep wells (pp. 470–480), and springs (pp. 481–488). The shallow-well data include range of depth of village wells, source, and yield; the deep-well data, depth, source, head, yield, quality, and uses; and the spring data, temperature, quality (including analyses), yield, source, uses, etc.

208 **Hamlin** (Homer). Water resources of the Salinas Valley, California.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 89, 91 pp., 1904.

Discusses underground waters under economic geology (pp. 21–23). Wells of stream deposits (p. 16); well statistics, including uses for irrigation, etc. (pp. 21–31); well records (pp. 31–32); and pumping from wells (pp. 82, 87) are other subjects considered.

209 **Harris** (Gilbert Dennison), **Dall** (William Healey) and. Correlation papers. Neocene.

See Dall (William Healey) and Harris (Gilbert Dennison).

210 **Harris** (Gilbert Dennison). Underground waters of southern Louisiana.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 101, pp. 11–73, 1904.

The paper includes discussions of the origin of underground waters (pp. 12–14); stratigraphy of southern Louisiana, including Oligocene, Miocene, and Quaternary horizons (pp. 17–26); well statistics and records (pp. 30–61); variation in flow and head (pp. 61–67); jetting and rotary processes of well drilling (pp. 68–71); analyses of well waters (pp. 44, 47–48); blowing wells (pp. 60–61); and pumping and use of screens (pp. 71–73). A brief account of certain Mississippi wells is included (pp. 30–33).

211 **Hawkins** (R.). Water supply of Livingston County [Missouri].

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 102, pp. 410–416, 1904.

Discusses the underground water conditions and gives detailed well records, etc.

212 **Haworth** (Erasmus). Underground waters of southwestern Kansas.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 6, pp. 65, 1897.

This paper discusses the original sources (p. 11), available amounts (p. 14), and geological conditions of ground water in general (p. 15), and describes the types and methods of locating ground waters (p. 18). The descriptions of the geography and geology of the area (pp. 19–37) are followed by a consideration of the source, occurrence, properties, flow, etc., of the waters of the Dakota sandstone (pp. 38–43), and of the Tertiary formations (pp. 43–57). The numerous and relatively shallow wells frequently used for irrigation and the springs of Meade County are considered (pp. 48–56). The writer concludes that there is an abundant supply both in the Arkansas Valley and on the uplands, but better means of raising it to the surface are needed (p. 62).

213 **Hay** (Robert). A geological reconnaissance in southwestern Kansas.

U. S. Geol. Surv., Bull. no. 57, pp. 49, 1890.

Notes occurrence of sulphate of lime in waters of Medicine River Valley, and describes the occurrence of water in the Dakota sandstone and in the Tertiary grits. Deep salt wells and borings (pp. 25–26) and artesian wells (pp. 13, 30, 48) are mentioned. The absorption of Bear Creek by its gravels is described.

214 —— Water resources of a portion of the Great Plains.

U. S. Geol. Surv., 16th Ann. Rept., pt. 2, pp. 535–588, 1896.

Describes and gives lists of springs of various water levels (pp. 545–547). Other topics considered are sources, catchment, etc., of the waters (pp. 550–557), volume (pp. 557–565), artesian flow (pp. 565–567), blowing wells (pp. 567–568), temperature (p. 568), geology and topography (pp. 569–579), water horizons of the Cretaceous, Tertiary, and Pleistocene formations (p. 580), and utilization of ground waters (pp. 585–586). Considerable supplies are obtainable, but not enough for all needs of irrigation and other purposes (pp. 586–588).

215 —— Geology of the Fort Riley Military Reservation and vicinity, Kansas.

U. S. Geol. Surv., Bull. no. 137, pp. 35, 1896.

In addition to the topography, geology, paleontology, etc., a number of copious springs, some used for water power, the flows of mineral waters in the wells of Geary County, and the value of the Carboniferous rocks, Tertiary gravels, and alluvium as sources of supplies are discussed (pp. 32–33). The occurrence of sinks is mentioned (pp. 15, 16, 26, and 27).

216 **Hayden** (F. V.). Administrative report [1884–85].

U. S. Geol. Surv., 6th Ann. Rept., pp. 48–53, 1885.

Notes progress of A. C. Peale on the bibliography of mineral waters and the preparation of a statistical paper (p. 53).

217 —— Administrative report [1885–86].

U. S. Geol. Surv., 7th Ann. Rept., pp. 85–87, 1888.

Mentions progress of work on mineral springs, and notes preparation of a second statistical paper and work on the bibliography of mineral waters by A. C. Peale.

218 **Hayes** (C. Willard). Ringgold folio, Georgia-Tennessee.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 2, pp. 3, 1894.
Ascribes the segregation of hematite, limonite, and manganese ores to the action of percolating underground waters (pp. 2–3).

219 —— Kingston folio, Tennessee.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 4, pp. 4, 1894.
Notes the disappearance of streams into underground channels or caves, and discusses the formation of "coves" or amphitheaters by the solution of limestone by underground waters (p. 1).

220 —— Chattanooga folio, Tennessee.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 6, pp. 3, 1894.
Disposition of limonite is referred to segregation in pockets or near the surface by percolating waters (p. 3).

221 —— Cleveland folio, Tennessee.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 20, pp. 4, 1895.
Refers the disposition of limonite ores to segregation by percolating waters (p. 4).

222 —— Pikeville folio, Tennessee.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 21, pp. 4, 1895.
Notes the occurrence of subterranean channels in region of Crab Orchard Mountains (p. 1).

223 —— The Arkansas beauxite deposits.
U. S. Geol. Surv., 21st Ann. Rept., pt. 3, pp. 435–472, 1901.
Provisionally ascribes origin of deposits to waters penetrating to heated syenite, dissolving parts of it, and returning to the surface as springs depositing beauxite (pp. 461–466).

224 —— Tennessee white phosphates.
U. S. Geol. Surv., 21st Ann. Rept., pt. 3, pp. 473–485, 1901.
Ascribes origin of ores to deposition from solution by underground waters in limestone cavities (p. 479).

225 —— Rome folio. Georgia-Alabama.
U. S. Geol. Surv., Geol. Atlas U. S., folio no. 78, p. 6, 1902.
Assigns the derivation of the limonite ores to the action of underground waters upon the Beaver limestone along its contact with the Weisner quartzite, and also along the contact of the Bangor limestone with the Oxmoor sandstone. Some iron has also been deposited by thermal springs along faults. In the formation of beauxite the surface waters penetrated downward to the Conasauga shale and, after dissolving out aluminum sulphate, passed upward along faults and deposited pisolitic grains of beauxite in springs (p. 6).

226 —— and **Kennedy** (William). Oil fields of the Texas-Louisiana Gulf Coastal Plain.
U. S. Geol. Surv., Bull. no. 212, p. 174, 1903.
In addition to the discussion of oil wells, mention or description is made of a considerable number of artesian (pp. 18, 33, 87, 118, 122) and thermal wells (pp. 60, 122). Lists of wells of the Jennings district, Louisiana (p. 130), and at Spindletop, Texas (pp. 77–85, 103–104), and records of a large number of gas, oil, and water wells at various points are given. The occurrence of sulphur in water (pp. 17, 18) and the relation of salt water to oil (p. 119) are discussed. A description of drilling methods is also given (pp. 166–170).

227 **Hayes** (C. Willard). Introduction. Contributions to economic geology, 1902.

U. S. Geol. Surv., Bull. no. 213, pp. 9–14, 1903.

Gives a table of the geologic folios of the survey, with lists of mineral products, including underground water, artesian water, and mineral springs.

228 —— and **Eckel** (E. C.). Iron ores of the Cartersville district Georgia.

U. S. Geol. Surv., Bull. no. 213, pp. 233–242, 1903.

The deposition of the ores is referred to solutions ascending from considerable depths along faults and other lines of passage.

229 **Hayes** (C. Willard). Oil fields of the Texas-Louisiana Gulf Coastal Plain.

U. S. Geol. Surv., Bull. no. 213, pp. 345–352, 1903.

Describes the occurrence of salt water in the Spindletop pool (p. 350).

230 —— origin and extent of Tennessee white phosphates.

U. S. Geol. Surv., Bull. no. 213, pp. 418–423, 1903.

Ores were deposited in quiet waters in caverns in the limestone, sometimes under hydrostatic pressure.

231 —— and **Eckel** (E. C.). Occurrence and development of ocher deposits in the Cartersville district, Georgia.

U. S. Geol. Surv., Bull. no. 213, pp. 427–432, 1903.

Notes the admission of surface waters to great depths by faults, and discusses the nature and movements of water connected with the formation of the ores (p. 429).

232 —— and **Ulrich** (Edward O.). Columbia folio, Tennessee.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 95, 6 pp., 1903.

Notes the occurrence of sinks, caves, and underground streams in the St. Louis limestone. Ordovician phosphates are ascribed to leaching of phosphatic limestones by acid surface waters along joint planes, etc. (pp. 5–6). The origin of blanket deposits through underground circulation and of collar deposits through capillary circulation are also considered (p. 6).

233 **Hayes** (C. Willard). Introduction: Contributions to economic geology, 1903.

U. S. Geol. Surv., Bull. no. 225, pp. 11–17, 1904.

Gives list of Survey publications and notes folios in which discussions of underground waters appear.

234 **Herrick** (H. N.). Gypsum deposits in New Mexico.

U. S. Geol. Surv., Bull. no. 223, pp. 89–99, 1904.

Notes presence of salt and hydrogen sulphide in wells penetrating the gypsum (p. 92), and the occurrence of sinks due to the solution of gypsum.

235 **Hilgard** (E. W.). Salines of Louisiana.

U. S. Geol. Surv., Min. Res. 1882, pp. 554–565, 1883.

Considers the wells and springs affording brines.

236 **Hill** (Benjamin F.). Gypsum deposits in Texas.

U. S. Geol. Surv., Bull. no. 223, pp. 68–73, 1904.

Notes impregnation of springs with gypsum, salt, and sulphur (p. 71), and mentions the filling of caves by the former mineral (p. 72).

237 **Hill** (Robert T.). The present condition of knowledge of the geology of Texas.

U. S. Geol. Surv., Bull. no. 45, pp. 95, 1887.

Describes the artesian-well experiment under Capt. John Pope in 1857–8 (p. 27).

238 —— Administrative report.

U. S. Geol. Surv., 15th Ann. Rept., pp. 170–171, 1895.

Describes artesian investigations in Texas (p. 171).

239 —— and **Vaughan** (T. Wayland). Geology of the Edwards Plateau and Rio Grande Plain adjacent to Austin and San Antonio, Texas, with reference to the occurrence of underground water.

U. S. Geol. Surv., 18th Ann. Rept., pt. 2, pp. 193–321, 1898.

Discusses the geography (pp. 201–212), geology (pp. 215–260), artesian principles (pp. 212–215), capacity of formations (pp. 260–264), and the underground waters, including artesian and nonflowing wells and springs of the Edwards Plateau (pp. 264–274) and the Rio Grande Plain (pp. 274–321). The identity of artesian and fissure spring waters in the latter, the source of the water, prospecting, chemical analyses, spring rivers, and fault springs are also considered, and the Edwards limestone and Travis Peak foundation discussed as sources of supply.

240 —— and **Vaughan** (T. Wayland). Nueces folio, Texas.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 42, pp. 4, 1898.

Describes caverns in limestones (p. 1), the honeycombed rocks of the Edwards formation (pp. 2–3), and notes the occurrence of springs and spring rivers throughout the Cretaceous (p. 2). Springs are divided into two groups, the fault springs, as those from Austin to Del Rio, and the gravity springs, as those of the Edwards formation (p. 3). Mentions the value of the Comanche Peak formation as a horizon marker in locating underground waters (p. 2). The Kickapoo water bed at the base of the Edwards formation, the Black Water Hole beds 150 feet higher, and the still higher Justice Spring horizon are described. They give nonflowing wells except along the Balcones fault (p. 4). Water is predicted in the Trinity beds 500 feet below the Comanche Peak limestone (p. 4).

241 **Hill** (Robert T.). Mineral resources of Porto Rico.

U. S. Geol. Surv., 20th Ann. Rept., pt. 6 cont., pp. 771–778, 1899.

Reports several thermal and mineral springs, some of which have been improved by the construction of baths, etc. Sulphur and ferruginous waters are the most common. An analysis of Coamo water is given (pp. 775–776).

242 **Hill** (Robert T.). Geography and geology of the Black and Grand prairies, Texas.

U. S. Geol. Surv., 21st Ann. Rept., pt. 7, pp. 1–666, 1900.

An elaborate report covering the geography of the Texas region, especially of the Black and Grand prairies (pp. 25–85), the geology (pp. 86–386), principles of the occurrence of underground waters (pp. 387–394), the artesian well systems of Texas (pp. 394–451), chemistry of the waters (pp. 447–451), and the artesian conditions of Black and Grand prairies by counties (pp. 452–649). The supplies are from the Cretaceous, including the base of the Trinity, a portion of the Glen Rose, the Paluxy, a part of the beds of the Edwards, Woodbine, and Denison formations and the Corsicana sands of the Navarro beds (p. 419).

243 —— and **Vaughan** (T. Wayland). Austin folio, Texas.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 76, pp. 8, 1902.

Notes the occurrence of interrupted streams and describes the springs of the honeycombed Edwards limestone (p. 2). The quadrangle is underlain by the Trinity group, which should furnish water rising 600 feet above sea level. The variations in depth of the beds are described (p. 8).

244 **Hills** (Richard Charles). Elmoro folio, Colorado.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 58, pp. 5, 1899.

Describes the artesian waters of the Dakota sandstone, together with the position, thickness, and depth of that bed. Strong flows are not probable, but small flows can be obtained in Purgatory Valley and elsewhere. The occurrence of springs is noted. In addition to the descriptions, a map showing the outcrop of the water horizon and the extent of and depths to the water bed in the flowing and nonflowing areas is given (pp. 4–5).

245 —— Walsenburg folio, Colorado.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 68, pp. 6, 1900.

Describes the Dakota sandstone and Lower Eocene beds and discusses the structure of the quadrangle. The prospects for flowing and nonflowing wells and the methods and cost of boring are considered, and the requisite conditions of artesian water are noted. A map showing the areas of outcrop of the Dakota sandstone and the Poison Canyon formation, the flowing, nonflowing, and unproductive areas, and the depth to the Dakota sandstone is given.

246 —— Spanish peaks folio, Colorado.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 71, pp. 7, 1901.

Discusses artesian conditions and the present and prospective supplies, and describes the Dakota sandstone and Poison Canyon formation. Notes the occurrence of springs. Gives a map showing areas underlain by water-bearing formations and the depth to the Dakota sandstone.

247 **Hobbs** (William Herbert). The Newark system of the Pomperang Valley, Connecticut.

U. S. Geol. Surv., 21st Ann. Rept., pt. 3, pp. 7–162, 1900.

Considers the rectilinear arrangement of certain springs as indicating fault lines (pp. 91–93).

248 **Holgate** (H. L.). The legal status of irrigation.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 93, pp. 296–300, 1904.

Devotes a section to underground waters, giving characteristic court decisions relating thereto (p. 299).

249 **Hollick** (Arthur). Cretaceous deposits of Staten Island. New York City folio, New York-New Jersey.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 83, pp. 10–11, 1902.

Notes the importance of the Cretaceous beds as a source of water supply, and mentions the drift and serpentine as additional sources.

250 **Hood** (Ozni Porter). New tests of certain pumps and water lifts used in irrigation.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 14, pp. 91, 1898.

A critical discussion of the various pumps and lifts used to raise underground waters to the surface.

251 **Hoyt** (John C.). Report of progress of stream measurements for the calendar year 1903. Part 4, Interior Basin, Pacific, and Hudson Bay drainage.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 100, pp. 533, 1904.

Gives spring measurements in Nevada (p. 227), mentions the springs of the San Francisco district (p. 277), describes briefly underflow and seepage at certain points in southern California (p. 339), and gives yield of wells and pumping plants in the same region (pp. 355–356).

252 **Hutson** (William Ferguson). Irrigation systems of Texas.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 13, pp. 68, 1898.

Discusses the pumping of underground waters for irrigation in the East Gulf Coast region (pp. 25–27), in central Texas (p. 29), along the Colorado River (p. 33), on the Llano Estacado (pp. 59–62), and at Laredo, Hidalgo, and Brownsville (pp. 58–59). The strong artesian flows near San Antonio and in the Pecos Valley, and the great San Marcos and Comal springs, together with the smaller springs of the Pecos Valley, are also described.

253 **Hydrography**, Division of. Operations at river stations, 1899. Part 2.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 36, pp. 198, 1900.

Gives the results of a number of spring measurements in Georgia (pp. 147–148).

254 —— Operations at river stations, 1899. Part 3.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 37, pp. 298, 1900.

Gives the result of spring measurements at Columbus, Nebr. (p. 276), and describes the big well at Uvalde, Tex., and the Las Moras and San Felipe springs, Texas (p. 277). The flow of the springs is 60 and 84 second-feet, respectively.

255 **Hydrography**, Division of. Operations at river stations, 1899. Part 5.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 39, pp. 471, 1900.

Gives measurements of the flows of artesian wells in the San Benardino Valley, California (p. 423).

256 —— Operations at river stations, 1900. Part 3.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 49, pp. 292, 1901.

Discusses the underground water supply of the South Platte Basin, Colorado (p. 279).

257 —— Operations at river stations, 1900. Part. 4.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 50, pp. 387, 1901.

Discusses seepage in Colorado (pp. 299–306, 320) and considers the underground waters of Arkansas Basin, Colorado (p. 320). The Barton (p. 335), San Antonio (p. 340), Leona (p. 342), San Felipe (p. 345), Toyale (p. 361), Saragossa (p. 362), and the springs of Lampasas River (p. 335), Nueces River (p. 343), and Mud Creek (p. 345), all of Texas, are described or mentioned, as are also the artesian wells of the San Antonio (p. 340).

258 —— Operations at river stations, 1900. Part 5.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 51, pp. 487, 1901.

Gives a number of discharge measurements of wells in California (pp. 482–484).

259 —— Operations at river stations, 1900. Part 6.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 52, pp. 575, 1901.

Describes the construction of wells in southern California (pp. 497–498).

260 —— Operations at river stations, 1901. Part 2 (west of Mississippi River).

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 66, pp. 188, 1902.

Notes the source of Mill Creek, Texas, in springs (p. 62), and describes the Carrizo Springs of Texas (p. 63) and the soda springs near the Tieton River, Washington (p. 135). An analysis of the waters of the Carrizo Springs (well) is given (p. 63).

I.

261 **Iddings** (Joseph P.) and **Weed** (Walter H.). Livingstone folio, Montana.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 1, pp. 4, 1894.

Describes travertine of present and extinct hot springs (p. 3).

262 **Irving** (John Duer). Economic resources of the northern Black Hills.

U. S. Geol. Surv., Professional Paper no. 26, pp. 222, 1904.

Mentions the relation of underground waters to ore deposits or mineralization (pp. 110, 136, 190), and gives a more complete discussion on pp. 155–157.

263 **Irving** (Roland Duer). On secondary enlargements of mineral fragments in certain rocks: Summary of general conclusions.

U. S. Geol. Surv., Bull. no. 8, pp. 48–52, 1884.

Ascribes enlargement of quartz grains in the Huron, Potsdam, and St. Peters quartzites to deposition from interstitially percolating waters (p. 49).

J.

264 **Jack** (John G.). Pikes Peak, Plum Creek, and South Platte [forest] reserves.

U. S. Geol. Surv., 20th Ann. Rept., pt. 5, pp. 39–115, 1899.

Notes the springs of the South Platte reserve (p. 92).

265 **Johnson** (Lawrence C.) **Smith** (Eugene A.) and. Tertiary and Cretaceous strata of the Tuscaloosa, Tombigbee, and Alabama rivers.

See Smith (Eugene A.) and Johnson (Lawrence C.)

266 **Johnson** (Laurence C.) and **Eckel** (Edwin C.). Mississippi. [Well records.]

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 102, pp. 332–357, 1904.

Considers briefly the general underground water conditions and gives a table of geologic and water horizons (pp. 332–333). Tables of a large number of wells, giving depths, head, quality, supply, geologic horizon of water, etc., are included.

267 **Johnson** (Willard D.). The high plains and their utilization.

U. S. Geol. Surv., 21st Ann. Rept., pt. 4, pp. 601–741, 1900.

Describes their character, origin, geological structure, and climate (pp. 609–679), and notes the necessity of additional water supplies (pp. 680–691). The occurrence of underground waters, including the catchment through basins, sinks, sod cracks, etc., resulting from solution or caving of Tertiary or Cretaceous beds is discussed, and the ground water conditions of the Meade artesian basin and other regions described. Both wells and springs are considered (pp. 702–741).

268 —— The high plains and their utilization.

U. S. Geol. Surv., 22d Ann. Rept., pt. 4, pp. 631–669, 1901.

Gives a physical description of the plains (pp. 637–640) and considers the occurence and origin of the underground waters (pp. 640–642). There appears to be enough water for watering stock, but not enough for extensive irrigation, except in valleys. The importance of correct well construction is emphasized (p. 669).

K.

269 **Keith** (Arthur). Knoxville folio, Tennessee-North Carolina.

U. S. Geol. Surv., Geol. Atlas of U. S., folio No. 16, pp. 6, 1895.

Describes springs and other sources of water supply of the region of the Knox dolomite, and notes the value of spring-fed streams for water power.

270 **Keith** (Arthur). London folio, Tennessee.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 25, pp. 6, 1896.
Describes underground drainage through sinks into the Rutledge limestone, and in the Knox dolomite (p. 3). States that the abundant springs of the region give rise to streams affording permanent power (p. 6).

271 —— Morristown folio, Tennessee.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 27, pp. 5, 1896.
Mentions the underground drainage of the Knox dolomite and that through sinks into subterranean channels in the Rutledge limestone (p. 2). Steady water power is derived from streams fed chiefly by springs.

272 —— Briceville folio, Tennessee.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 32, pp. 4, 1896.
Describes the underground drainage and sinks of the Knox dolomite (p. 2).

273 —— Maynardville folio, Tennessee.
U. S. Geol. Surv.,Geol. Atlas of U. S., folio no. 75, pp. 6, 1901.
Notes the underground drainage and sinks of the Rutledge limestone and Knox dolomite (p. 2) and mentions the sulphur springs of the Chattanooga shale (p. 4).

274 —— Cranberry folio.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 90, pp. 9, 1903.
Mentions the occurrence of multitudes of springs feeding the streams, many of which have valuable water powers.

275 —— Recent zinc mining in East Tennessee.
U. S. Geol. Surv., Bull. no. 225, pp. 208–218, 1904.
Notes deposition of ores by ground waters and the occurrence of hot springs in limestones (p. 212).

276 **Kennedy** (William) **Hayes**, (C. W.) and. Oil fields of the Texas-Louisiana Gulf Coastal Plain.
See Hayes (C. W.) and Kennedy (William).

277 **King** (Franklin Hiram). Principles and conditions of the movements of ground water.
U. S. Geol. Surv., 18th Ann. Rept., pt. 2, pp. 59–294, 1897.
Among the subjects discussed are the water-holding capacity of soils and rocks (pp. 70–71); the gravitational, thermal, capillary, and seepage movements, and movements due to crust deformation and rock consolidation (pp. 71–94); experimental investigations of movements through wire gauze, tubes, rocks, sands, soils, etc. (pp. 107–206); movements through sand and rock in nature (pp. 207–292); influence on flow of form, diameter, and arrangement of grains (pp. 207–218, 228–242); determination of pore space and size of grains (pp. 218–228); movements over wide areas and in fissures (pp. 245–250); interference of wells (pp. 276–279); flow into wells (pp. 279–289); computation of capacity (pp. 289–290); flow into driven well points (pp. 290–292), and rate of pumping of different classes of wells (pp. 292–293).

L.

278 **La Forge** (Laurence) **Crosby** (William O.) and. Massachusetts. [Well and spring records.]

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 102, pp. 94–111, 1904.

See Crosby (William O.) and La Forge (Laurence).

279 **Lane** (Alfred C.). Water resources of the lower peninsula of Michigan.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 30, pp. 97, 1899.

Treats of the uses of surface and underground waters (pp. 11–48), climate (pp. 48–57), well temperatures (p. 56), geology and topography, including descriptions of shallow wells, methods of sinking wells (p. 69), deep wells of the Carboniferous, Devonian, and Silurian rocks (pp. 77–89), rock structure (pp. 90–91), and prospects in various districts (pp. 91–94).

280 —— Lower Michigan mineral waters. (A study into the connection between their chemical composition and mode of occurrence.)

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 31, pp. 97, 1899.

Considers the economic value of water (pp. 12–14) and discusses analyses of the waters of lakes, streams, wells, springs, etc. (pp. 14–57). The chemistry of the waters of the various geological formations, including the Marshall and Berea Grit and the Devonian and Silurian limestones, is treated at some length (pp. 58–86). Special attention is given to the brines (pp. 66–70).

281 **Langille** (H. D.). Forest conditions in the Cascade Forest Reserve, Oregon: Northern portion of Cascade Range Forest Reserve.

U. S. Geol. Surv., Prof. Paper no. 9, pp. 27–69, 1903.

Describes hot mineral springs (p. 28).

282 **Lee** (Willis T.). Underground waters of Salt River Valley [Arizona].

U. S. Geol. Surv., 2d Ann. Rept. Reclamation Service, 1902–3, pt. 73–76, 1904.

Describes the underflow and the various water horizons. Pumping for irrigation is proposed.

283 —— The underground waters of Gila Valley, Arizona.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 104, pp. 71, 1904.

Among the topics discussed are wells (pp. 14–23), return waters (pp. 23–25), underflow, including rate of movement and volume (pp. 26–63, 67, 68), composition of ground waters, including analyses (pp. 15, 20, 57, 61), well descriptions and records (pp. 14–23), capacity of wells and well tests (pp. 16–18), seepage ditches (pp. 23–25, 51–52), porosity of gravels (pp. 47–48), experiments with underflow (pp. 40–47), and pumping plants (pp. 52–57).

284 **Leiberg** (John B.). Priest River Forest Reserve [Idaho].

U. S. Geol. Surv., 19th Ann. Rept., pt. 5, pp. 217–252, 1898.

In connection with the discussion of water supplies the collection of water in fissured granite and its emergence as springs is noted (p. 220).

285 —— Bitterroot Forest Reserve [Montana].

U. S. Geol. Surv., 19th Ann. Rept., pt. 5, pp. 253–282, 1898.

Springs are numerous and give rise to small streams. It is thought that they might be used for irrigation (pp. 259–260).

286 —— The San Gabriel Forest Reserve [California].

U. S. Geol. Surv., 20th Ann. Rept., pt. 5, pp. 411–428, 1899.

Notes the absorption of water into the rocks and the reappearance as springs (p. 415).

287 —— The San Bernardino Forest Reserve.

U. S. Geol. Surv., 20th Ann. Rept., pt. 5, pp. 429–454, 1899.

Notes the disappearance of streams in gravel (p. 433) and mentions the practice of tunneling to intercept ground water (p. 435). Describes the artesian basins of the reserve (p. 435).

288 —— Cascade Range Forest Reserve [Oregon]; Ashland Forest Reserve.

U. S. Geol. Surv., 21st Ann. Rept., pt. 5, pp. 209–498, 1900.

Notes the occurrence of large springs giving rise to streams (p. 225) and the presence of hot springs (p. 229). Mention is made of the disappearance of streams into the lava (p. 231).

289 —— Forest conditions in the Cascade Forest Reserve, Oregon: Southern part of the Cascade Range Forest Reserve.

U. S. Geol. Surv., Prof. Paper no. 9, pp. 229–289, 1903.

Describes springs (pp. 239, 264, 281, 283) and notes absorption of water by pumice (p. 234) and by fissures in the lava (pp. 276, 281).

290 —— **Rixon** (Theodore F.), and **Dodwell** (Arthur). Detailed descriptions [of timber of townships]. Forest conditions in the San Francisco Mountains Forest Reserve, Arizona.

U. S. Geol. Surv., Prof. Paper no. 22, pp. 35–91, 1904.

Gives occasional references to springs in connection with discussion of forest conditions.

291 **Leiberg** (John B.). Forest conditions in the Little Belt Mountains Forest Reserve, Montana, and the Little Belt Mountains Quadrangle.

U. S. Geol. Surv., Prof. Paper no. 30, 75 pp., 1904.

Mentions springs under "Drainage conditions" in some of the township descriptions.

292 **Leighton** (Marshall Ora). Sewage pollution in the metropolitan area near New York City and its effect on inland water resources.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 72, pp. 75, 1902.

Discusses the normal composition of underground waters, including the normal chlorine, and mentions the loss of mechanical sediments and gain in material in solution in the passage of water into the ground.

293 **Leighton** (Marshall Ora). Normal and polluted waters in northeastern United States.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 79, pp. 192, 1903.

Notes the removal of albuminoid ammonia by natural filtration and discusses the normal composition, especially the chlorine constituent of ground and seepage waters. Points out the necessity of storing such waters in covered reservoirs on account of the abundant nitrates which favor algous growth (pp. 22–31).

294 —— Quality of water in the Susquehanna River drainage basin.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 108, 76 pp., 1904.

Describes coal mine waters (pp. 24–26) and the underground waters of the Chemung Valley of New York and Pennsylvania (pp. 51–52), the west branch of the Susquehanna (pp. 53–56) and the Juniata (pp. 63–65). Analyses of waters from mines, springs, wells, and streams are given.

295 **Leith** (Charles Kenneth), **Van Hise** (Charles Richard), **Clements** (J. Morgan) and. Iron-ore deposits of Lake Superior region.

See Van Hise (C. R.), and Leith (C. K.), and Clements (J. Morgan).

296 **Leith** (Charles Kenneth). The Mesabi iron-bearing district of Minnesota.

U. S. Geol. Surv., Mon., vol. 43, 316 pp., 1903.

Discusses the relation of water level to ores, waters in mines, etc. (pp. 234–235), the processes of alteration, including analyses (p. 265) and the laws of circulation (pp. 265–272). The ores are considered to have been derived from greenalite-bearing sedimentary rocks or from carbonates by the action of underground waters (pp. 237–238), the alteration taking place both above and below the water level. The presence of phosphates in waters from ores and the concentration of the ores by water is considered (pp. 274–275), and the influence of percolating water in the formation of other Lake Superior ores is noted (pp. 277–279).

297 —— Geologic work in the Lake Superior iron district, 1902.

U. S. Geol. Surv., Bull. no. 213, pp. 247–250, 1903.

Considers the relation of underground waters to ore deposition (pp. 249–250).

298 —— Iron ores in southern Utah.

U. S. Geol. Surv., Bull. no. 225, pp. 228–237, 1904.

Notes agency of percolating waters in ore deposition (p. 235).

299 —— The Lake Superior iron region during 1903.

U. S. Geol. Surv., Bull. no. 225, pp. 215–220, 1904.

Notes deposition of ores of Menominee district, Michigan, by circulating waters (p. 216).

300 **Leverett** (Frank). The water resources of Illinois.

U. S. Geol. Surv., 17th Ann. Rept., pt. 2, pp. 695–849, 1896.

Considers topography and drainage (pp. 703–717), rainfall (pp. 718–730), run-off (pp. 730–742), navigable waters (pp. 744–746), water powers (pp. 746–748), drift and shallow and deep rock wells, supplies for towns or cities (pp. 748–765), and rural supplies (pp. 765–782). A chapter is devoted to artesian wells, including a discussion of the geology and of the altitude, capacity, casing, head, and quality of water (pp. 785–818). A considerable number of analyses are given (pp. 819–829).

301 —— The water resources of Indiana and Ohio.

U. S. Geol. Surv., 18th Ann. Rept., pt. 4, pp. 419–559, 1897.

After considering the physical features, drainage, lakes, etc., of the region (pp. 426–474) a discussion of underground waters, including wells of the drift, shallow and deep rock wells, subterranean drainage lines, springs, analyses of the waters, etc., is given (pp. 474–501). This is followed by extended descriptions of the water supplies of cities and villages (pp. 502–559).

302 —— The Illinois glacial lobe.

U. S. Geol. Surv., Mon., vol. 38, 817 pp., 1899.

Gives a chapter on the wells of Illinois (pp. 550–787), in which a classification of underground waters, a discussion of artesian conditions, and detailed descriptions of the wells by counties, with many records, are included.

303 —— Wells of northern Indiana.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 21, pp. 82, 1899.

Gives maps showing distribution of drift and the relation of wells to the drift. Discusses the general conditions of underground supplies and describes and gives records of many wells, both flowing and nonflowing.

304 —— Wells of southern Indiana. (Continuation of Water Supply and Irrigation Paper no. 21.)

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 26, pp. 64, 1899.

Discusses the relations of wells to the geology, including both drift and rock, and describes and gives records of a large number of wells.

305 —— Danville folio, Illinois-Indiana. Underground water.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 67, pp. 7–9, 1900.

Gives a detailed discussion of underground waters and of wells, including both open and tubular, flowing and nonflowing, and drift and rock types. The problems of catchment and head are considered. More than a hundred records giving altitude, depth, head, etc., are included.

306 —— Glacial formations and drainage features of the Erie and Ohio basins.

U. S. Geol. Surv., Mon., vol. 41, 802 pp., 1902.

No special discussion of the waters of the drift is given, although many incidental references to wells and records are included, especially to the flowing wells of Ohio (see index of monograph).

307 **Lindgren** (Waldemar) and **Turner** (H. W.). Marysville folio, California.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 17, pp. 2, 1895.

Gives deep-well records at Marysville Buttes and discusses the value of wells as sources of water supply. Some of the water is charged with carbonates and sulphates.

308 **Lindgren** (Waldemar). The gold quartz veins of Nevada City and Grass Valley districts, California.

U. S. Geol. Surv., 17th Ann. Rept., pt. 2, pp. 1–262, 1896.

Notes the occurrence of strong ascending springs along the quartz veins (pp. 120–124), and ascribes the deposition of the ores to ascending thermal waters containing carbonates, silica, alkaline sulphates and sulphides, and metals (pp. 173, 262). Analyses of the water and deposits show carbonates and sulphates of Ca, Mg, Mn, As, Fe, Pb, Mo, etc., and silica (pp. 121–123). The amount of silica is compared with that of waters of Iceland geysers, Steamboat Springs, Nebraska, and Yellowstone National Park (p. 176).

309 —— The mining districts of the Idaho Basin and the Boise Ridge, Idaho.

U. S. Geol. Surv., 18th Ann. Rept., pt. 3, pp. 617–719, 1897.

Notes the occurrence of a hot mineral spring on a fault at Warm Spring (p. 667).

310 —— Boise folio, Idaho.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 45, pp. 7, 1898.

Notes the use of springs for irrigation (p. 1). The springs are especially numerous and copious in the sheeted granite area. Several large springs, some hot and weakly mineralized, occur in the Payette formation. The artesian wells of the granite and of the Neocene and Pleistocene formations, especially the Payette, are considered and the best locations discussed. The occurrence of hot artesian mineral waters near Boise is noted (p. 7).

311 —— The gold and silver veins of Silver City, De Lamar, and other mining districts in Idaho.

U. S. Geol. Surv., 20th Ann. Rept., pt. 3, pp. 65–256, 1899.

Describes silicious spring deposits with some gold and silver deposited by thermal waters at De Lamar (pp. 103–104), and the hydrothermal alteration of granite, basalt, and rhyolite are discussed from the chemical side (pp. 174–186). Notes the occurrence of hot artesian waters carrying gold and silver at De Lamar (p. 187), and mentions the deposition of ores by carbonated waters in the Wood River district (p. 217).

312 —— Colfax folio, California.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 66, pp. 10, 1900.

Mentions the numerous and copious springs of the igneous rocks and in the auriferous Neocene river gravels. They sometimes interfere seriously with mining (p. 10).

313 —— The gold belt of the Blue Mountains of Oregon.

U. S. Geol. Surv., 22d Ann. Rept., pt. 2, pp. 551–776, 1901.

Notes the occurrence of ascending thermal waters (p. 615) and describes thermal mineral springs and their deposits, giving analyses (pp. 641–642).

314 **Lindgren** (Waldemar.) The water resources of Molokai, Hawaiian Islands.

U. S. Geol. Surv., Water-Supply and Irrigation Paper, no. 77, pp. 62, 1903.

Discusses the physical conditions (p. 9–26), ground-water conditions, quality, etc. (pp. 26–28), low and high level springs (pp. 28–30), available ground water (pp. 47–49, 59), and the present and prospective uses for irrigation (p. 56). The wells, which are mostly shallow and uncertain as to the amount of water and as to the salt in solution, are described (pp. 37–47).

315 —— and **Drake** (N. F.). Nampa folio, Idaho-Oregon.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 103, pp. 5, 1904.

Gives a number of well records (p. 2), notes the work of hot springs in lake beds (p. 2), and describes the general occurrence of thermal springs, ground waters, and artesian wells (p. 5).

316 —— and **Drake** (N. F.). Silver City folio, Idaho.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 104, pp. 6, 1904.

Discusses in detail the occurrence of warm-spring and artesian waters and wells, giving a table of depths and temperatures of water of the latter (pp. 5–6).

317 **Lindgren** (Waldemar). A geological reconnaissance across the Bitteroot Range and Clearwater Mountains in Montana and Idaho.

U. S. Geol. Surv., Prof. Paper no. 27, pp. 116, 1904.

Describes the mineral springs of the region and their temperature, and notes their use for bathing, etc. (pp. 113–114).

318 —— and **Ransome** (Frederick Leslie). Report of progress in the geological resurvey of the Cripple Creek district, Colorado.

U. S. Geol. Surv., Bull. no 254, pp. 36, 1904.

Contains a section on underground waters in which depth of ground water and oxidation, mine waters, occurrence of water in joints of crystalline rocks and drainage by tunnels are considered (pp. 31–32).

319 **Lippincott** (Joseph Barlow). Water supply of San Bernardino Valley.

U. S. Geol. Surv., 19th Ann. Rept., pt. 4, pp. 540–633, 1898.

Describes springs and their flow (pp. 563–564), and discusses the artesian wells fed by ground water and by underflow from San Antonio Creek (pp. 565–566).

320 —— Storage of water on Kings River, California.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 58, pp. 101, 1902.

Discusses the ground water of Kings River delta, from which abundant supplies are obtained (pp. 53–84), and gives statistical tables giving for the wells the depth, character of water-bearing beds, quality of water, methods of lifting, cost, and the amount, use, and saline contents of the waters. Seepage and its effect on ground-water level is noted (pp. 22–24, 80–82) and the alkalinity and replenishment of the ground water described (pp. 82–88).

321 **Lippincott** (Joseph Barlow). Development and application of water near San Bernardino, Colton, and Riverside, California. Part I.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 59, pp. 95, 1902.

Describes the artesian district (p. 22), the rate of underflow (p. 22), analyses (p. 23), details of artesian area, including amount and permanancy of supply (pp. 38–42), pumping (pp. 42–46), irrigation, springs and wells of Riverside district (p. 62), and wells of the Gage canal system (pp. 69–78).

322 —— Development and application of water near San Bernardino, Colton, and Riverside, California. Part II.

U. S. Geol. Surv., Water-Supply and Irrigation Paper, no. 60, pp. 102–141, 1902.

Discusses the artesian wells in the East Riverside district, in the Redlands and San Bernardino quadrangles, in the vicinity of Rincon, etc., and gives tables (pp. 115–134) showing type of wells, depth, height of water, character of strata, quality of water, method of lifting, quantity, and cost of water. Seepage in the San Bernardino Valley is also considered (pp. 108, 113).

323 —— California hydrography.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 81, pp. 488, 1903.

Describes the gravel fan at the base of the mountains at Pasadena Mesa. The gravel is saturated with water which is collected by wells and tunnels. Well statistics, including depth, flow, etc., are given (pp. 174–180).

324 **Lord** (Eliot). Comstock mining and miners.

U. S. Geol. Surv., Mon., vol. 4, 451 pp. 1883.

Gives a chapter on "The contest with water," describing the immense flows of thermal waters encountered and the methods of meeting the problems (pp. 230–244). Other incidental references to mine waters occur.

M.

325 **Martin** (George C.). Petroleum fields of Alaska and the Bering River coal fields.

U. S. Geol. Surv., Bull. no. 225, pp. 365–382, 1904.

Notes the occurrence of oil, gas, and sulphur springs (pp. 368, 378), and mentions the finding of large flows of water (p. 379). Underground water is assigned a part in the accumulation and distribution of ore (p. 369).

326 **Matthes** (Gerard H.). Grand River project [Colorado].

U. S. Geol. Surv., Second Ann. Rept. Reclamation Service, 1902–3, pp. 210–250, 1904.

Notes the settling of the ground because of accretions to the ground water through irrigation (pp. 213, 236).

327 **McCallie** (S. W.). Georgia. [Water supply, well, and spring records.]

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 102, pp. 207–236, 1904.

Gives tables showing the sources of public supplies (pp. 208–221) and tables and notes on wells (pp. 221–225) and springs (pp. 227–236). The data on public supplies includes source, quality, special uses, etc., on wells, the depth, head, quality, analyses, and yield; and on springs, quality, odor, taste, sediment, mineral deposits, yield, source, uses, improvements, and analyses.

328 **McGee** (W J). The geology of the head of Chesapeake Bay.

U. S. Geol. Surv., 7th Ann. Rept., pp. 537–646, 1888.

The investigation was made to determine the artesian conditions near Fishing Battery Station. Reviews the conditions necessary for artesian supplies and discusses the local structure and displacements in addition to a general consideration of Coastal Plain conditions. A moderate supply rising nearly to the surface is predicted from the Potomac sands (pp. 644–645).

329 —— Administrative report [1886–87].

U. S. Geol. Surv., 8th Ann. Rept., pt. 1, pp. 166–173, 1889.

Notes bearing of data collected at the head of Chesapeake Bay on artesian waters along the fall line.

330 —— Administrative report [1887–88].

U. S. Geol. Surv., 9th Ann. Rept., pp. 102–110, 1889.

Mentions the artesian well prospects of the Fort Riley Military Reservation, Kansas (p. 104), and notes an arrangement with A. J. Phinney to collect boring records in Indiana (p. 105).

331 —— Administrative report [1888–89].

U. S. Geol. Surv., 10th Ann. Rept., pt. 1, pp. 148–158, 1890.

Notes progress of the survey of the Fort Riley Military Reservation with a view of determining the water supply and other economic products (p. 154).

332 —— The Pleistocene history of northeastern Iowa.

U. S. Geol. Surv., 11th Ann. Rept., pt. 1, pp. 189–577, 1891.

Describes solution caverns in the Galena limestone and their ores (p. 329), and gives well sections in northeastern Iowa and adjacent portions of Illinois. They are mainly geological, but some notes on water are given (pp. 514–540).

333 —— Introduction: Rock gas and related bitumens. The natural gas field of Indiana, by Arthur John Phinney.

U. S. Geol. Surv., 11th Ann. Rept., pt. 1, pp. 589–616, 1891.

Notes the correspondence of laws governing the accumulation of the of lighter hydrocarbons and artesian waters and considers the requisites for artesian flows (pp. 603–604).

334 **McGee** (W J). The potable waters of the eastern United States.

U. S. Geol. Surv., 14th Ann. Rept., pt. 2, pp. 1–47, 1893.

Besides rain and stream water, the accumulation and utilization through wells or springs of shallow ground water (pp. 40–42), and the accumulation, underground conditions, etc., of "phreatic" or deep-seated waters of thermal springs and of artesian and other deep wells are considered, and local statistics given (pp. 42–47).

335 —— Administrative report [1892–93].

U. S. Geol. Surv., 14th Ann. Rept., pt. 1, pp. 210–244, 1893.

Notes work of the Survey on potable waters of wells and springs, the occurrence of artesian waters of District of Columbia, at Fortress Monroe, and at Cristield, Maryland (pp. 216, 219), work on the artesian waters of Missouri (p. 232), and studies on general water supplies, including wells (p. 237). A summary of work on artesian waters is also given (p. 230).

336 **Mead** (Elwood). Water-right problems of the Bighorn Mountains.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 23, pp. 62, 1899.

Notes loss by seepage from Little Tongue River and loss through funnels, etc., in limestone (p. 49).

337 **Means** (Thomas H.). The use of alkaline waters for irrigation.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 93, pp. 255–258, 1904.

Notes the use of highly alkaline artesian waters for irrigation in Algiers (pp. 255, 258).

338 **Murphy** (Edward Charles). Windmills for irrigation.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 8, pp. 49, 1897.

In addition to the critical discussion of the use of windmills as a means of raising ground water for irrigation, a brief description is given of the wells near Garden, Kansas (p. 10).

339 —— The windmill: its efficiency and economic use. Part I.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 41, pp. 72, 1901.

Discusses the types and uses of windmills and gives the results of elaborate tests of their efficiency in raising ground water. The artesian wells near Garden, Kansas are also described (pp. 22–23).

340 —— The windmill: its efficiency and economic use. Part II.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 42, pp. 73–147, 1901.

Describes further tests relating to the efficiency of windmills in raising ground water to the surface.

341 **Murphy** (Edwin C.). Destructive floods in the United States in 1903.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 96, 81 pp., 1904.

In connection with the flood descriptions the author considers ground storage of water and its effect on the flow of streams (pp. 71–73.) Figures as to amount of porosity are given (p. 272).

N.

342 **Newell** (Frederick Haynes). Hydrography of the arid regions.
U. S. Geol. Surv., 12th Ann. Rept., pt. 2, pp. 213–361, 1891.
Discusses mainly the flow and uses of surface waters, but incidentally considers the wells of the Rio Grande Valley (pp. 247, 278), the large alkaline springs near Puerto de Luna (p. 284), the springs of Agua Negra (p. 205), Peers (p. 285), Berenda (p. 286), North Spring, Hondo, Block, and Seven rivers (p. 286), Gallinas springs (p. 287), and springs of the San Pedro district (p. 304). Lost and underground rivers are noted in several instances (pp. 232–234, 282, 287, 315).

343 —— Water supply for irrigation.
U. S. Geol. Surv., 13th Ann. Rept., pt. 3, pp. 1–99, 1892.
Estimates a total of 8,097 artesian wells in Western United States in 1890, 3,930 of which are used for irrigating 51,896 acres. In addition there is a still greater number of pumped wells (p. 28). The movement of water through rock and sediments and the use of underflow canals is considered (pp. 29–30). The use of seepage waters for irrigation near the Jefferson River, Montana (p. 52), and the deep wells at Helena (p. 55) are described.

344 —— Administrative report.
U. S. Geol. Surv., 15th Ann. Rept., pp. 196–198, 1895.
Describes work on artesian problems (p. 196).

345 —— Report of progress of the division of hydrography for the calendar years 1893 and 1894.
U. S. Geol. Surv., Bull. no. 131, pp. 126, 1895.
Contains an account of seepage along the Cache la Poudre River, Colorado, and the absorption of water by the bed of the Platte River (pp. 31–32). Tables of well records giving the location, year completed, diameter, depth, depth to water, cost of well and machinery, etc., for a large number of wells in Nebraska, Colorado, and Kansas are included (pp. 92–126).

346 —— The public lands and their water supply.
U. S. Geol. Surv., 16th Ann. Rept., pt. 2, pp. 457–533, 1896.
Gives information relating to the deep wells or springs of Arizona (p. 505), California (p. 509), Colorado (p. 511), Idaho (p. 512), Indian Territory (p. 512), valley of the Arkansas in Kansas (p. 514), of North Platte River, Nebraska (p. 517), New Mexico (p. 520), North Dakota (p. 521), Oklahoma (p. 522), South Dakota (p. 523), and of Texas (p. 524). Other subjects considered are supplies of streams from underground waters (p. 470), seepage (pp. 471, 529), pumping (p. 517), and wells as a source of supply for irrigation (pp. 499–502).

347 —— Report of progress of the division of hydrography for the calendar year 1895.
U. S. Geol. Surv., Bull. no. 140, pp. 356, 1896.
Mentions the springs of the sand-hill region of North Carolina (p. 65) and the San Marcos, San Felipe, Las Mosas, Leona, and the springs of Comal River and San Antonio, Texas (pp. 83–85). The seepage of the Ogden Valley, Utah (p. 223), the artesian supply of Caliente Valley, California (p. 267), the underground conditions and supply at Lindsay, California (p. 279), and seepage measurements in Nebraska (pp. 347–349) are also given.

348 **Newell** (Frederick Haynes). Preface. Pumping water for irrigation. By Herbert M. Wilson.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 1, pp. 11–13, 1896.

Defines scope and plan for the new series of papers of which this is the first, and gives a list of some of the surface and underground water problems under investigation.

349 —— Letter of transmittal: Hydrography.

U. S. Geol. Surv., 18th Ann. Rept., pt. 4, pp. VII–VIII, 1897.

Mentions work of Frank Leverett, N. H. Darton, and F. F. B. Coffin on underground waters.

350 —— Introduction: Hydrography.

U. S. Geol. Surv., 18th Ann. Rept., pt. 4, pp. IX–X, 1897.

Reviews work of Survey on streams and underground waters from 1888 to 1896.

351 —— Letter of transmittal: Underground waters of southwestern Kansas. By Erasmus Haworth.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 6, p. 9, 1897.

States object of investigatation.

352 —— Letter of transmittal: Seepage Water of northern Utah. By Samuel Fortier.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 7 (p. 9), 1897.

Gives a statement of the importance of underground seepage.

353 —— Letter of transmittal: Hydrography.

U. S. Geol. Surv., 19th Ann. Rept., pt. 4, pp. VII–VIII, 1898.

Describes work and papers of Edward Orton and N. H. Darton on underground waters of Ohio and Nebraska respectively.

354 —— Report of progress of stream measurements for the calendar year 1897.

U. S. Geol. Surv., 19th Ann. Rept., pt. 4, pp. 111, 539, 1898.

Describes or mentions the springs of Shenandoah Valley, Virginia, and the water supplies of the towns (p. 136), the catchment area of the Dakota sandstone and the artesian basins of the Arkansas Valley in Colorado, as investigated by G. K. Gilbert (p. 352), the hot springs of the Bitterroot Forest Reserve, Montana (p. 401), the artesian wells of the Moxee Valley, Washington (with records), and the large springs near the Deschutes River, a tributary of the Columbia basin, Washington (p. 497).

355 —— Letter of transmittal: Underground waters of a portion of southeastern Nebraska. By N. H. Darton.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 12, p. 9, 1898.

Describes character of the work and plans for future investigations.

356 **Newell** (Frederick Haynes). Introduction. Irrigation systems in Texas. By William Ferguson Hutson.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 13, pp. 9–16. 1898.

Considers in some detail the cost, capacity, and profit of pumping underground waters for irrigation.

357 —— Report of progress of stream measurements for the calendar year 1898.

U. S. Geol. Surv., 20th Ann. Rept., pt. 4, pp. 1–562, 1899.

Gives a summary of hydrographic investigations (p. 19) and describes the work on underground waters, artesian wells, pumping, and windmills (p. 44), and in the Black Hills and Bad Lands, by N. H. Darton (p. 252). Other topics relating to underground waters which are considered are the springs of Cache La Poudre River (p. 240), artesian wells of the Arkansas Valley, Colorado (p. 340), ground-water conditions in the Mississippi Valley (p. 350), use for irrigation and power of the springs of San Antonio River, Texas (p. 355), the hot sulphur waters of Steamboat Springs, California (pp. 384, 387), underground waters of the southern Ute Indian Reservation (p. 412), seepage in Boise Valley (p. 484), artesian well records, artesian wells of Moxee Valley, Washington (p. 508), artesian well discharge measurements (p. 509), underground water at Arroyo Seco and Pasadena Mesa, California, with records (pp. 543–549), and artesian wells of the San Bernardino Valley, California (p. 539).

358 —— Introduction. Experiments with windmills. By Thomas O. Perry.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 20, pp. 11–18, 1899.

Gives a general discussion of the uses of windmills in raising underground waters for irrigation and other purposes.

359 —— Letter of transmittal. Wells of northern Indiana. By Frank Leverett.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 21, p. 7, 1899.

States the nature of Mr. Leverett's work and gives reasons for publication in present form.

360 —— Letter of transmittal. Wells and windmills of Nebraska. By Erwin Hinckley Barbour.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 29, pp. 11–12, 1899.

Discusses the value of windmills, especially the horse-made types, in developing underground waters.

361 —— Letter of transmittal. Hydrography.

U. S. Geol. Surv., 21st Ann. Rept., pt. 4, p. 7, 1900.

Notes the importance of work of N. H. Darton in the Black Hills region, South Dakota, and mentions that of W. D. Johnson on the High Plains.

362 **Newell** (Frederick Haynes). Report of progress of stream measurements for the calendar year 1899.

U. S. Geol. Surv., 21st Ann. Rept., pt. 4, pp. 9–488, 1900.

The report incidentally discusses the work of the Survey on underground waters (p. 27); the pumping of underground waters for irrigation in Georgia (p. 142); loss of water from the bed of Black Warrior River, Alabama (p. 152); the work of A. W. Palmer on the analysis of well and spring waters of Illinois (p. 178); springs of Yellowstone National Park (p. 190); ground water at Kearney, Nebraska (p. 26); springs at Mesa Verde and in cliff and Navajo Canyon, Colorado (p. 297); seepage in Mancos Canyon, Colorado (p. 294); artesian wells and seepage measurements in Arizona (pp. 252, 376, 379), and artesian or underground water in the San Antonio basin and along Lytle Creek and San Diego River, California (pp. 481, 482, 486).

363 —— Letter of transmittal. Hydrography.

U. S. Geol. Surv., 22d Ann. Rept., pt. 4, p. 7, 1901.

Mentions the paper of W. D. Johnson on "The High Plains and their Utilization."

364 —— Report of progress of stream measurements for the calendar year 1900.

U. S. Geol. Surv., 22d Ann. Rept., pt. 4, pp. 9–506, 1901.

Notes the value of artesian waters in desert lands (p. 49); mentions the springs near Johnson City, Tennessee, and gives analysis (pp. 231–233); describes the disappearance of water in sinks in the Thunder Bay region of Michigan (p. 261), and discusses the water resources, including artesian and other underground waters in southeastern Idaho (pp. 421–430), and in the Kings River Basin of California (pp. 479–480).

365 —— Letter of transmittal. Reconnaissance of Yuba River, California, by Marsden Manson.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 46, pp. 9–10, 1901.

Notes the advantages of wind and electric power in raising underground waters.

366 —— Letter of transmittal. Development and application of water near San Bernardino, Colton, and Riverside, California. Part 1, by Joseph Barlow Lippincott.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 59, pp. 95, 1902.

Discusses the resort to tunnels and wells for water supplies.

367 —— Letter of transmittal. The motions of underground waters. By Charles S. Slichter.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 67, pp. 106, 1902.

States the object and scope of the investigations of underground waters.

368 —— Letter of transmittal. Geology and water resources of the Patrick and Goshen Hole quadrangles in eastern Wyoming and western Nebraska. By George I. Adams.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 70, p. 9, 1902.

Points out the importance of the observations in the two quadrangles, which are typical of much of the public-land area in this region.

369 **Newell** (Frederick Haynes). Report of progress of stream measurements for the calendar year 1901.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 75, p. 246, 1903.

Describes the discharge of artesian wells in Moxee Valley, near North Yakima, Washington (pp. 204–205).

370 —— Report of progress of stream measurements for the calendar year 1902. Part 1, North Atlantic coast and St. Lawrence River drainage.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 82, pp. 199, 1903.

Discusses the necessity of data regarding depth, rate of flow, cost, etc., of artesian wells (p. 9).

371 —— Report of progress of stream measurements for the calendar year 1902. Part 2, southern Atlantic, eastern Gulf, and Great Lakes drainage.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 83, pp. 304, 1903.

Discusses the storage of water and possible loss by subterranean flow from sand belt of the Cape Fear basin, North Carolina (pp. 30, 60), the removal of ground water by ditching (p. 242), the ground waters north of Saginaw Bay, Michigan (p. 294), and the absorption of water by limestone in the Thunder Bay region, Michigan (p. 296).

372 —— Report of progress of stream measurements for the calendar year 1902. Part 3, western Mississippi River and western Gulf drainage.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 84, pp. 200, 1903.

Describes the character and flow of the large Barton Springs, near Austin, Texas (pp. 152–153), the Sloan Spring at the edge of the Edwards plateau, Texas (p. 155), and the San Felipe Springs at Del Rio, Texas (p. 161).

373 —— Report of progress of stream measurements for the calendar year 1902. Part 4, interior basin, Pacific coast, and Hudson Bay drainage.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 85, 250 pp., 1903.

Mentions inflow of rivers into Carson Sink, Nevada (pp. 78–79)

374 —— First Annual Report of the Reclamation Service.

June 17 to December 1, 1902, 317 pp. Atlas, 1903.

Quotes old laws authorizing investigation of underground currents and artesian waters (p. 36), and gives section of reclamation law covering the same point (pp. 61–63). Other underground-water topics treated are: Use of springs for irrigation in Idaho (p. 172), underflow in Kansas (p. 200), ground waters of Musselshell River basin, Montana (pp. 215–220), artesian investigations in Nebraska (p. 220), irrigation by underground waters (p. 196), springs of Nevada (p. 224), artesian waters of Oregon (p. 273) and South Dakota (p. 278), and artesian prospects on the Columbia p ains of Washington (p. 304).

375 **Newell** (Frederick Haynes). General discussion, organization, and summary of work.

U. S. Geol. Surv., 2d Ann. Rept. Reclamation Service, 1901–2, pp. 21–70, 1904.

Notes limitations imposed on Reclamation Service in regard to sinking deep wells (pp. 25–27, 39), and mentions pumping from underground waters in Kansas (p. 59).

376 —— Proceedings of first conference of engineers of the Reclamation Service with accompanying papers. Report of conference.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 93, pp. 1–116, 1904.

Mentions the work of Mr. N. H. Darton and of the western section of hydrology (p. 11), and gives an account of the organization of the hydrologic division (pp. 15, 16).

377 **Noble** (T. A.). Investigations in Washington.

U. S. Geol. Surv., 2d Ann. Rept. Reclamation Service, 1902–3, pp. 487–498, 1904.

Notes underground course of Crab Creek for most of course (p. 490).

O.

378 **Olmstead** (Frank H.). Physical characteristics of Kern River, California.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 46, pp. 11–38, 1901.

Describes the wells near Bakersfield which are perforated at each water horizon (p. 28).

379 **Orton** (Edward). The Trenton limestone as a source of petroleum and inflammable gas in Ohio and Indiana.

U. S. Geol. Surv., 8th Ann. Rept., pt. 2 (pp. 475–662), 1889.

Notes the penetration of surface waters into oil wells (p. 511) and the position of brine with reference to oil and gas. Analyses of salt water from the Trenton, Niagara, and Upper Helderberg, which form a special type of "limestone brines," are given. Some are used for bottling and medicinal purposes (p. 621). Notes the limitation of progress of water and oil by dolomitization (p. 644).

380 —— Rock waters of Ohio.

U. S. Geol. Surv., 19th Ann. Rept., pt. 4, pp. 633–717, 1898.

Discusses the geology (pp. 638–650) and considers the waters of the Trenton limestone, the Medina and Clinton horizons, Niagara, Onondaga, and Corniferous limestones, the Ohio shale, the rocks of the Waverly group, and the conglomerate and other Carboniferous beds (pp. 651–696). Flowing rock wells and artesian wells of buried glacial channels are described (pp. 697–717).

P.

381 **Parker** (Edward W.). Salt [1892].

U. S. Geol. Surv., Min. Res. of U. S., 1892, pp. 792–800, 1893.

Gives production of salt from wells, springs, and other sources for the year 1892.

382 **Parker** (Edward W.). Salt [1893].
U. S. Geol. Surv., Min. Res. of U. S., 1893, pp. 717–727, 1894.
Gives production of salt from wells, springs, and other sources for the year 1893.

383 —— Salt [1894].
U. S. Geol. Surv., 16th Ann. Rept., pt. 4, cont., pp. 646–657, 1895.
Gives production of salt from wells, springs, and other sources for the year 1894.

384 —— Salt [1895].
U. S. Geol. Surv., 17th Ann. Rept., pt. 3, cont., pp. 984–997, 1896.
Gives production of salt from wells, springs, and other sources for the year 1895.

385 —— Salt [1896].
U. S. Geol. Surv., 18th Ann. Rept., pt. 5, cont., pp. 1273–1314, 1897.
Gives production of salt from wells, springs, and other sources for the year 1896.

386 —— Salt [1897].
U. S. Geol. Surv., 19th Ann. Rept. pt. 6, cont., pp. 587–612, 1898.
Gives production of salt from wells, springs, and other sources for the year 1897.

387 —— Salt [1898].
U. S. Geol. Surv., 20th Ann. Rept., pt. 6, cont., pp. 667–688, 1899.
Gives production of salt from wells, springs, and other sources for the year 1898.

388 —— Salt [1899].
U. S. Geol. Surv., 21st Ann. Rept., pt. 6, cont., pp. 531–554.
Gives production of salt from wells, springs, and other sources for the year 1899.

389 —— Salt [1900].
U. S. Geol. Surv., Min. Res. of U. S., 1900, pp. 835–848, 1901.
Gives production of salt from wells, springs, and other sources for the year 1900.

390 **Peale** (Albert C.). Mineral waters.
U. S. Geol. Surv., Min. Res. of U. S., 1883–84, pp. 978–987, 1885.
Gives a list of mineral spring localities. States the output for 1883 as 47,289,743 gallons, with a value of $1,139,483, and for 1884 as 68,720,936 gallons, with a value of $1,665,490. Statistics of imports and exports are included.

391 —— Mineral waters.
U. S. Geol. Surv., Min. Res. of U. S., 1885, pp. 536–543, 1886.
A list of mineral spring localities and statistics of production, exports, and imports are given. The output for the year is given as 9,148,401 gallons, with a value of $1,312,845. The decrease in production is due to the exclusion of the artesian wells used for the public supply at Madison, Wisconsin.

392 **Peale** (Albert C.). Lists and analyses of the mineral springs of the United States (a preliminary study).

U. S. Geol. Surv., Bull. no. 32, pp. 235, 1886.

Discusses the flow, temperature, classification, and composition of 657 springs from 405 localities. One hundred and eighty-seven analyses are given. Seventy-four springs are developed as resorts and 72 are used commercially.

393 —— Mineral waters.

U. S. Geol. Surv., Min. Res. of U. S., 1886, pp. 715–721, 1887.

Includes the usual list of spring localities and statistics of production, imports, and exports. The total output for 1886 is given as 8,950,317 gallons, with a value of $1,284,070.

394 —— Mineral waters.

U. S. Geol. Surv., Min. Res. of U. S., 1887, pp. 680–687, 1888.

Spring localities are listed and statistics of production, import, and export given. The output for the year is placed at 8,259,609 gallons, with a value of $1,261,473.

395 —— Administrative report [1886–87].

U. S. Geol. Surv., 8th Ann. Rept., pt. 1, pp. 146–148, 1889.

Details progress of work on mineral waters and mentions papers published during the year.

396 —— Administrative report [1887–88].

U. S. Geol. Surv., 9th Ann. Rept., pp. 111–114, 1889.

Notes the preparation of a third paper on the statistics of mineral waters.

397 —— Administrative report [1888–89].

U. S. Geol. Surv., 10th Ann. Rept., pt. 1, pp. 130–132, 1890.

Mentions the work of Charles W. Redmond on mineral waters (p. 132).

398 —— Mineral waters.

U. S. Geol. Surv., Min. Res. of U. S., 1888, pp. 623–630, 1890.

The production for 1888 is stated as 9,578,648 gallons. Its value was $1,679,302. Both production and value show an increase over previous year. Other statistics and a list of springs are given.

399 —— Administrative report [1889–90].

U. S. Geol. Surv., 11th Ann. Rept., pt. 1, p. 82, 1891.

Mentions his assignment to the Eleventh Census to take charge of mineral waters.

400 —— Administrative report [1890–91].

U. S. Geol. Surv., 12th Ann. Rept., pt. 1, pp. 91–92, 1891.

Describes work on mineral waters for the Survey and for the Eleventh Census.

401 —— Administrative report [1891–92].

U. S. Geol. Surv., 13th Ann. Rept., pt. 1, p. 124, 1892.

Describes work on mineral water statistics.

402 **Peale** (Albert C.). Mineral waters.

U. S. Geol. Surv., Min. Res. of U. S., 1889–90, pp. 521–536, 1892.

The number of springs reporting in 1889 was 258, their product 12,780,471 gallons, and the value of the water $1,748,458. In 1890, 273 springs reported an output of 13,907,418 gallons, with a value of $2,600,750. Other statistics and lists of springs are given.

403 —— Mineral waters.

U. S. Geol. Surv., Min. Res. of U. S., 1891, pp. 601–610, 1893.

This year 288 springs, with a production of 18,392,732 and value of $2,996,259, reported. Lists of springs and detailed statistics are presented.

404 —— Mineral waters.

U. S. Geol. Surv., Min. Res. of U. S., 1892, pp. 823–834, 1893.

In 1892 aggregate sales amounting to 21,876,604 gallons, with a value of $4,905,976, were reported by 283 springs. The usual statistics and lists of springs are included in the paper.

405 —— Mineral waters.

U. S. Geol. Surv., Min. Res. of U. S., 1893, pp. 772–794, 1894.

The number of springs reporting sales in 1893 was 330; the total amount sold, 23,544,495 gallons, and the value, $4,246,743. In addition to the usual statistics and list of commercial springs a list of springs used as resorts is given.

406 —— Natural mineral waters of the United States.

U. S. Geol. Surv., 14th Ann. Rept., pt. 2, pp. 49–88, 1894.

Discusses the history (pp. 53–57), origin (pp. 58–59), flow (pp. 59–61), source of mineralization (p. 61), relation to geology and geologic structure (pp. 62–64), classification (pp. 64–68), temperature (p. 68), composition (pp. 69–73), distribution (pp. 73–80), and uses of springs (pp. 80–81), and their development as resorts (pp. 81–88).

407 —— Mineral waters [1894].

U. S. Geol. Surv., 16th Ann. Rept., pt. 4, pp. 707–721, 1895.

A large falling off of production due to business depression is recorded. Total shipments in 1894 were 21,569,608 gallons, with a value of $3,741,846. Statistics of production, with summaries of exports and imports, are given.

408 —— Three Forks folio, Montana.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 24, pp. 5, 1896.

Describes sulphated alkaline saline thermal waters at Ferris Hot Springs, which resemble the Carlsbad Sprudel Springs. Other hot springs are mentioned (p. 5).

409 —— Mineral waters [1895].

U. S. Geol. Surv., 17th Ann. Rept., pt. 3, cont., pp. 1025–1044, 1896.

Gives product for 1895 as 21,463,543 gallons, a loss of 106,665 gallons from that of the previous year. The value, however, increased from $3,741,846 to $4,254,237. The product by States from 1883 to 1895 (pp. 1026–1031), lists of commercial springs (pp. 1031–1040), and statistics of imports and exports (pp. 1043–1044) are also given.

410 **Peale** (Albert C.). Mineral waters [1896].

U. S. Geol. Surv., 18th Ann. Rept., pt. 5, cont., pp. 1369–1389, 1897.

The statistics of production are given by States. The total sales in 1896 amount to 25,795,312 gallons, with a value of $4,136,192. These figures show a marked increase in volume, but a slight decrease in value. Lists of commercial springs and figures showing exports and imports are presented.

411 —— Mineral waters [1897].

U. S. Geol. Surv., 19th Ann. Rept., pt. 6, cont., pp. 659–685, 1898.

The year 1897 showed the largest number of springs yet reported, namely, 381. The production was 23,255,911 gallons, a slight decrease; but the value, which was $4,599,106, showed an increase over 1896. Production by States and districts, lists of commercial springs, and exports and imports are also given.

412 —— Mineral waters [1898].

U. S. Geol. Surv., 20th Ann. Rept., pt. 6, cont., pp. 747–769, 1899.

The output in 1898 is given as 28,853,464 gallons, with a value of $8,051,833, a large increase over 1897. Statistics of production by States, exports, imports, and lists of commercial springs are given.

413 —— Mineral waters [1899].

U. S. Geol. Surv., 21st Ann. Rept., pt. 6, cont., pp. 597–622, 1900.

Gives the product for 1899 as 39,562,136 gallons, with a value of $6,948,030; an increase of 10,708,672 gallons and decrease of $1,103,803. The products by States and districts, lists of commercial springs, imports, and exports are given.

414 —— Mineral waters.

U. S. Geol. Surv., Min. Res. of U. S., 1900, pp. 899–905, 1901.

Gives statistics of production, export and import, placing the total output as 47,558,784 gallons, with a value of $6,245,172. The number of springs reporting was 491.

415 [——] Mineral waters.

U. S. Geol. Surv., Min. Res. of U. S., 1901, pp. 961–966, 1902.

Gives statistics of production and of exports and imports. The total output for the year is given as 55,771,188 gallons, with a value of $7,586,962. The number of springs reporting was 659.

416 [——] Mineral waters [1902.]

U. S. Geol. Surv., Min. Res. of U. S. for 1902, pp. 993–1002, 1904.

Gives product for 1902 as 64,859,451 gallons, with a value of $8,793,761. The number of springs (721), output, and value all show an increase over the previous year.

417 [——] Mineral waters [1903.]

U. S. Geol. Surv., Min. Res. of U. S. for 1903, pp. 1137–1162, 1904.

The production of 725 springs is estimated at 51,242,757 gallons, valued at $9,041,078. The number of springs and value is the greatest ever recorded. A list of the springs of the United States is given.

418 **Penrose**, Jr. (R. A. F.). Mining geology of the Cripple Creek district, Colorado.

U. S. Geol. Surv., 16th Ann. Rept., pt. 2, pp. 111–209, 1896.

Considers the part of underground waters in ore deposition (p. 160).

419 **Peppel** (S. V.). Gypsum deposits in Ohio.
U. S. Geol. Surv., Bull. no. 223, pp. 38–44, 1904.
Notes sulphuratted hydrogen in gypsum mines and bore holes (p. 39), and gives record of boring (p. 43).

420 **Perkins** (George H.). Vermont. [Town water supplies, analyses, and well and spring records.]
U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 102, pp. 73–93, 1904.
Gives tables showing sources of water of towns and cities (pp. 73–76), a large number of sanitary analyses of public and other supplies (pp. 77–81), tables and notes relating to wells (pp. 83–87), and to springs (pp. 87–93). The well data includes quality, yield, source of supply, and records; the spring data, yield, quality, source of water, temperature, and uses.

421 **Perry** (Thomas O.). Experiments with windmills.
U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 20, pp. 97, 1899.
A general description of experiments resulting in several improvements in the methods of raising ground water by windmills.

422 **Phinney** (Arthur John). The natural-gas field of Indiana.
U. S. Geol. Surv., 11th Ann. Rept., pt. 1, pp. 579–742, 1891.
Gives a large number of boring records, mainly geological. Discusses the relation of water to oil and gas, noting the rise of salt water to an average level of 600 feet (pp. 654–655), and ascribes the change of surface waters to brines (p. 656). The Trenton limestone is a great reservoir for water under hydrostatic pressure (pp. 656–663), the flow depending on porosity (pp. 657–658). A table of water pressures is given (p. 663).

423 **Pirsson** (Louis Valentine), **Weed** (Walter Harvey) and. Geology of the Castle Mountain mining district, Montana.
U. S. Geol. Surv., Bull. no. 139, p. 104, 1896.
See Weed (Walter H.) and Pirsson (Louis Valentine).

424 —— **Weed** (Walter Harvey) and. Geology and mineral resources of the Judith Mountains of Montana.
U. S. Geol. Surv., 18th Ann. Rept., pt. 3, pp. 437–616, 1897.
See Weed (Walter Harvey) and Pirsson (Louis Valentine).

425 **Plummer** (Fred G). Mount Rainier Forest Reserve, Washington.
U. S. Geol. Surv., 21st Ann. Rept., pt. 5, pp. 81–143, 1900.
Describes soda-iron-sulphur springs, giving analysis (pp. 94–96).

426 —— Forest conditions in the Cascade Range, Washington.
U. S. Geol. Surv., Prof. Paper no. 6, p. 42, 1902.
Describes a number of important common and hot soda and sulphur springs and gives an analyses of the water. Hotels using the waters for medicinal and bathing purposes are located at Hot Springs and Madison (pp. 37–39).

427 **Plummer** (Fred G.). Forest conditions in the Cascade Forest Reserve, Oregon: Central portion of Cascade Range Forest Reserve.

U. S. Geol. Surv., Prof. Paper no. 9, pp. 71–146, 1903.

Describes Breitenbush Hot Springs, Belknap Springs, and other hot and sulphur springs used for bathing, etc. The spring deposits are also described and an analysis of the water given (pp. 77–78).

428 —— Introduction: Forest conditions in the San Francisco Mountains Forest Reserve, Arizona.

U. S. Geol. Surv., Prof. Paper no. 22, pp. 11–35, 1904.

Mentions the sparing occurrence of springs and the absorption of water by the lava beds (pp. 16, 31).

429 —— and **Gowsell** (M. G.). Forest conditions in the Lincoln Forest Reserve, New Mexico.

U. S. Geol. Surv., Prof. Paper no. 33, 47 pp., 1904.

Mentions mineral wells (p. 17) and contains important references to common wells at a number of places.

430 **Powell** (John Wesley). Report of the Director [1883–84].

U. S. Geol. Surv., 5th Ann. Rept., pp. I–XXXVI, 1885.

Mentions the work of Dr. A. C. Peale on the preparation of a bibliography of thermal springs.

431 —— Report of the Director [1885–86]: Work in the Division of Mining Statistics and Technology.

U. S. Geol. Surv., 7th Ann. Rept., pp. 38–39, 1888.

The output of mineral waters in 1885 is given as 9,148,401 gallons, with a value of $1,312,845.

432 —— Report of the Director [1886–87].

U. S. Geol. Surv., 8th Ann. Rept., pp. 1–93, 1889.

Designates the work of Gooch and Whitfield on the mineral waters of the Yellowstone National Park as "the most complete study of mineral waters of any locality with special reference to their agency in mineral formation ever placed on record" (p. 84). Gives the product of mineral waters for 1886 as 8,950,317 gallons, with a value of $1,284,070 (p. 86).

433 —— Report of the Director [1887–88].

U. S. Geol. Surv., 9th Ann. Rept., pp. 1–46, 1889.

Notes the progress of work in the Yellowstone National Park (p. 16), and mentions the work of A. C. Peale on mineral waters (p. 21). The product of mineral waters for 1887 is stated as 8,259,609 gallons, with a value of $1,261,473 (p. 26).

434 —— Report of the Director [1888–89].

U. S. Geol. Surv., 10th Ann. Rept., pt. 1, pp. 3–80, 1890.

Describes the work in Yellowstone National Park and notes changes and irregularites of geyser action. The discovery of the sulphide of arsenic in the spring waters is announced (pp. 24–25). The extravasation of thermal waters in Florida is mentioned (p. 33). The product of mineral waters for 1888 is given as 9,628,568 gallons, with a value of $1,709,302.

435 **Powell** (John Wesley.) United States Irrigation Survey, First Annual Report, 1888–89.

U. S. Geol. Surv., 10th Ann. Rept., pt. 2, pp. 123, 1890.

Describes the transfer of surface streams to underground courses (p. 26).

436 —— Report of the Director [1889–90].

U. S. Geol. Surv., 11th Ann. Rept., pt. 1, pp. 1–30, 1891.

Gives the product of mineral waters in 1889 as 20,000,000 gallons, with a value of $3,000,000 (p. 20). Notes the discovery of oil and gas by borings suggested by the escape of gas from springs (p. 26).

437 —— United States Irrigation Survey, Second Annual Report, 1889–90.

U. S. Geol. Surv., 11th Ann. Rept., pt. 2, pp. 395, 1891.

Mentions and defines artesian reservoirs and "sand reservoirs" of underground waters (pp. 204–205). Notes the disappearance by absorption of Saginaches River of the Rio Grande Basin (p. 216). Describes the basins, water horizons, conditions, and sources of water of the artesian wells of the Dakotas (pp. 257–260), and makes a prediction that artesian reservoirs will not furnish important supplies for irrigation (p. 260). General artesian conditions, the Denver Basin of Colorado, the Dubuque wells of Iowa, the Chicago and Rockford wells of Illinois, the wells of Ohio and of Alabama are also considered (pp. 260–262). Other subjects discussed are irrigation from wells in Algeirs and other foreign countries, and the Dakota sandstone as a source of artesian waters. Lists of wells in Minnesota, North Dakota, South Dakota, Nebraska, Kansas, and Texas are given and the prediction made that pump wells will prove of more ultimate value than artesian wells.

438 —— Report of the Director [1890–91].

U. S. Geol. Surv., 12th Ann. Rept., pt. 1, pp. 1–19, 1891.

The output of mineral waters for 1890 is stated as 14,000,000 gallons, with a value of $2,000,000 (p. 15).

439 —— Report of the Director [1891–92].

U. S. Geol. Surv., 13th Ann. Rept., pt. 1, pp. 1–66, 1892.

Describes investigations of temperatures in deep well at Wheeling, West Virginia (p. 37), and mentions work on underground waters in Colorado, Florida, Iowa, Kansas, Louisiana, Montana, New Jersey, South Dakota, Texas, Virginia, and Washington (pp. 33–34). The output of mineral waters for 1891 is given as 18,392,732 gallons, with a value of $2,996,259 (pp. 45, 51).

440 —— Report of the Director [1892–93].

U. S. Geol. Surv., 14th Ann. Rept., pt. 1, pp. 1–165, 1893.

Mentions the work of F. H. Newell on artesian and underground waters in South Dakota, Nebraska, and Kansas (p. 20), and of A. C. Peale on thermal and mineral springs (p. 25). The work of the Survey on geysers and hot springs, and on temperature observations in the Wheeling deep well is described (pp. 158–159). The unreliability of underflow is pointed out (p. 47).

441 **Powell** (John Wesley). Report of the Director [1893–94].

U. S. Geol. Surv., 15th Ann. Rept., pp. 1–108, 1895.

Gives the production of mineral waters for 1893 as 23,544,495 gallons, with a value of $4,246,734 (p. 72). Contains an abstract of Bull. no. 108, "A geological reconnaissance in central Washington, by Israel C. Russel" (p. 101).

442 **Pressey**, (Henry Albert). Hydrography of the southern Appalachian Mountain Region. Part 1.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 62, pp. 95, 1902.

Describes or mentions springs of Grandfather Mountain, North Carolina (p. 19), Holsten River region, Tennessee (p. 40), Indian Creek, Tennessee (p. 54), Mill Creek, Virginia (p. 68), Hogthief Creek, Virginia (p. 74), and Watauga River, Tennessee (p. 82). The springs of Indian Creek are used for power (p. 54). An underground lakelet and sinks in the Watauga River region (p. 82) and sinks along Buffalo Creek, Tennessee (p. 87), are mentioned.

443 —— Hydrography of the southern Appalachian Mountain Region. Part 2.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 63, pp. 190, 1902.

Notes common, hot, and mineral springs, and sinks of the French Broad in North Carolina and Tennessee (pp. 116–122) and describes the Piedmont mineral springs and others of Upper Creek, North Carolina (p. 156). Also refers to springs of Grandfather Mountain, North Carolina (p. 158).

444 —— New York City folio, New York-New Jersey. Water supply of New York City.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 83, pp. 17–19, 1902.

Gives a history of the development of the public supplies, including descriptions of the early wells. Mentions the well supply of Elizabeth and notes the occurrence of strong wells in the Newark formation, as at Pattison. Describes the ground-water well supplies of Brooklyn and the boroughs of Queens and Richmond, and discusses the availability of the ground water and streams of Long and Staten islands as sources of additional supplies.

445 **Prosser** (Charles S.) and **Beede** (J. W.). Cottonwood Falls folio, Kansas.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 109, pp. 6, 1904.

Describes springs of Wriford limestone (p. 3).

446 **Purdue** (A. H.). Arkansas. [Well and spring records.]

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 102, pp. 374–388, 1904.

Discusses the general underground water conditions (pp. 374–375) and gives tables and notes on wells (pp. 376–384) and springs (pp. 385–388). The well statistics include depth, head, yield, quality (including analyses), records, and uses; the spring data, temperature, quality (including analyses), yield, source, uses, etc.

447 **Purington** (Chester Wells). Preliminary report of the mining industries of the Telluride quadrangle, Colorado.

U. S. Geol. Surv., 18th Ann. Rept., pt. 3, pp. 745–850, 1897.

Discusses the origin of heated waters and their work in vein formation (pp. 819–824), and considers the relation of ground-water level to mining (p. 826). Springs depositing iron oxides at Ophir Valley and in the La Plata Mountains are described (pp. 826–827).

R.

448 **Raborg** (William A.). Salt.

U. S. Geol. Surv., Min. Res., 1886, pp. 628–641, 1887.

The brines of the wells of Michigan and the springs and wells of New York are discussed.

449 —— Salt.

U. S. Geol. Surv., Min. Res., 1887, pp. 610–625, 1888.

The brines of the wells of West Virginia and Ohio and of the springs and wells of New York are considered and analyses given of the Ohio waters.

450 —— Salt.

U. S. Geol. Surv., Min. Res., 1888, pp. 597–612, 1890.

Salt wells of New York and Kansas are listed and described and the composition of brines discussed.

451 —— Salt.

U. S. Geol. Surv., Min. Res., 1889–1890, pp. 483–492, 1892.

Gives information pertaining to the salt wells of Michigan and New York.

452 **Rafter** (George W.) Sewage irrigation.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 3, pp. 100, 1897.

Discusses removal of suspended matter and bacteria of sewage waters in passage downward into the earth.

453 —— Sewage irrigation. Part 2.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 22, pp. 100, 1899.

Gives mechanical analyses of sands in relation to their water-holding capacities (pp. 31–33).

454 —— Water resources of the State of New York. Part 1.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 24, pp. 99, 1899.

Discusses the relation of character of rock to absorption of rainfall (pp. 21–22) and describes big springs near Morris Run, Wyoming County, and Canadaway Creek, Chautauqua County (pp. 93–94).

455 —— Water resources of the State of New York. Part 2.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 25, pp. 100–200, 1899.

Describes leakage from Glen Falls, feeder of Erie Canal, into limestone, amounting to 53 per cent of volume (pp. 159–160), and discusses the loss of water by absorption, etc., from artificial channels (pp. 173–178). Describes the wells of Long Island, both deep and shallow, including the flowing wells of the Brooklyn Water Company and the wells of the sand areas (pp. 191–198).

456 **Rafter** (George W.). The relation of rainfall to run-off.
U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 80, pp. 104, 1903.
Discusses the variations of level of ground water (p. 17), storage of water in soils, and feeding of streams (pp. 43–45) and movements of underground waters (p. 45). Underground streams or channels are noted in Mammoth and Lauray caves, and near Toyah Creek, Texas, and in the upper Mohawk region in Schoharie County, New York.

457 **Ransome** (Frederick Leslie), **Turner** (H. W.) and. Sonora folio, California.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 41, pp. 7, 1897.
See Turner (H. W.) and Ransome (F. L.).

458 **Ransome** (Frederick Leslie). Some lava flows of the western slope of the Sierra Nevada, California.
U. S. Geol. Surv., Bull. no. 89, pp. 74, 1898.
Describes strong springs from andesitic breccias (p. 22).

459 —— and **Turner** (H. W.). Big trees folio, California.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 51, pp. 8, 1898.
See Turner (H. W.) and Ransome (F. L.).

460 **Ransome** (Frederick Leslie). The ore deposits of the Rico Mountains, Colorado.
U. S. Geol. Surv., 22d Ann. Rept., pt. 2, pp. 229–397, 1901.
Regards the ores to have been derived from the rocks by percolating thermal waters (p. 302) and considers their deposition in blankets to have taken place when there was solution and caving of the gypsum beds, etc. (pp. 294–303).

461 —— A report on the economic geology of the Silverton quadrangle, Colorado.
U. S. Geol. Surv., Bull. no. 182, pp. 265, 1901.
Assigns the deposition of ores to ascending mineralized waters along fissures (p. 133) and discusses the descending sulphurous waters of the Red Mountain region (p. 135), the relation of ground waters to mining (p. 141), the mineral waters of mines (p. 113), and the ferruginous springs of the region. The limonite deposits of the last are described and an analyses of the waters given (pp. 113–114).

462 —— Geology of the Globe copper district, Arizona.
U. S. Geol. Surv., Professional Paper no. 12, pp. 168, 1903.
Ascribes origin of ore to deposition by ascending, originally meteoric, solutions. Original sulphides were later enriched by oxidation by superficial waters (pp. 128–132).

463 —— The geology and ore deposits of the Bisbee quadrangle, Arizona.
U. S. Geol. Surv., Professional Paper no. 21, pp. 168, 1904.
Gives a number of well sections (pp. 74–75), notes trouble with mine waters (p. 119), and discusses the relation of ground water to oxidation (pp. 145–146) and to ore deposition (pp. 134, 153–154).

463a **Ransome** (Frederick Leslie). Globe folio. Arizona.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 111, pp. 17, 1904.
Notes the relation of underground waters to ore deposition (p. 16), and describes the absorption of streams and the occurrence of springs and wells (p. 17).

464 —— **Lindgren** (Waldemar) and. Report of progress in the geological resurvey of the Cripple Creek district, Colorado.
U. S. Geol. Surv., Bull. no. 254, pp. 36, 1904.
See Lindgren (Waldemar) and Ransome (Frederick Leslie).

465 **Ransome** (Frederick Leslie) Bisbee folio. Arizona.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 112, pp. 17, 1904.
Considers ground water and its relation to alteration of ores, discusses the part of water in ore formation, and describes the artesian waters, wells, and springs of the vicinity (pp. 16–17).

466 **Reed** (W. M.). Water storage on Hondo River, New Mexico.
U. S. Geol. Surv., 2d Ann. Rept. Reclamation Service, pp. 380–387, 1904.
Notes importance of springs and artesian waters (p. 381).

467 **Richardson** (George B.). Indiana folio. Pennsylvania.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 102, pp. 7, 1904.
Gives deep-well record (p. 2), describes the occurrence of artesian waters in synclines and their use for town supplies, etc. (p. 7).

468 **Ries** (Heinrich). The clays of the United States east of the Mississippi River.
U. S. Geol. Surv., Prof. Paper no. 11, 298 pp., 1903.
Gives a number of sections of rocks, including clay shales in Pennsylvania, Ohio, West Virginia, and Virginia, some apparently being based in whole or in part on borings.

469 **Rixon** (Theodore F.), **Dodwell** (Arthur) and. Forest conditions in the Cascade Forest Reserve, Oregon; Cascade Range Forest Reserve between townships 18 and 29 south.
U. S. Geol. Surv., Prof. Paper no. 9, pp. 147–227, 1903. See Dodwell (Arthur) and Rixon (Theodore F.).

470 **Rixon** (Theodore), **Leiberg** (John B.), and **Dodwell** (Arthur). Detailed description [of timber of townships]. Forest conditions in the San Francisco Mountains Forest Reserve, Arizona.
U. S. Geol. Surv., Prof. Paper no. 22, pp. 35–91, 1904.
See Leiberg (John B.), Rixon (Theodore), and Dodwell (Arthur).

471 **Rizer** (H. C.) The United States Geological Survey; its origin, development, organization, and operations.
U. S. Geol. Surv., Bull. no. 227, 205 pp., 1904.
Notes the work of the section of chemistry on spring waters (p. 51), and gives an account of the early work of the Survey on underground waters and the organization and present work of the division of hydrology (pp. 84–88). Mention is made of work in New York, New Jersey, Georgia, Louisiana, Arkansas, Missouri, Minnesota, Wisconsin, Arizona, California, and the Dakotas. A list of survey publications is appended.

472 **Robbins** (S. B.) Reconnaissance on Musselshell River, [Montana].

U. S. Geol. Surv., 2d Ann. Rept. Reclamation Service, pp. 252–254, 1904.

Mentions the occurrence of springs, underflow, and waters available for shallow wells (p. 353).

573 **Ross** (D. W.). Investigations in Idaho.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 93, pp. 174–176, 1904.

Notes the absorption of streams by great lava flows and the breaking out of springs in canyons (p. 174).

474 **Russell** (Israel Cook). Sketch of the geological history of Lake Lahontan.

U. S. Geol. Surv., 3d Ann. Rept., pp. 189–237, 1883.

Discusses the theoretical structure of spring deposits as compared with Lake Lahonton deposits (p. 219).

475 —— A geological reconnaissance in southern Oregon.

U. S. Geol. Surv., 4th Ann. Rept., pp. 431–464, 1883.

Describes the association of hot springs and faults in the Stein Mountains at Warner and Sumner lakes, and in Surprise Valley. Regards high temperature to have resulted from the arrested motion of orographic blocks, and that hot springs outside the volcanic areas may be taken as indicating recent faults (pp. 445–452).

476 —— Geological history of Lake Lahontan, a Quaternary lake of northwestern Nevada.

U. S. Geol. Surv., Mon., vol. 11, pp. 288, 1885.

Discusses recent and extinct springs at some length (pp. 47–54), describing hillside and fissure types, hot springs and their deposits, temperature of springs, and composition (including analyses). The occurrence of springs on fault lines is noted (pp. 53, 276, 279, 283) and springs in lakes described (pp. 220–222). The chemistry of spring water and their gases, including analyses, is considered (pp. 175–178), and the tufa deposits mentioned (pp. 187, 220–222). Brines of wells and springs are also treated (pp. 232–235).

477 —— Quaternary history of Mono Valley, California.

U. S. Geol. Surv., 8th Ann. Rept., pt. 1, pp. 261–394, 1889.

Describes the numerous and copious cold and warm springs of the ordinary and of the fissure or fault type, giving analyses. The sublacustral springs forming strong eddies in the lake and building up tufa cones are of special interest. In general the waters are pure and deposits are not now forming. One spring is frequently sufficient to irrigate several acres. The hot springs are taken to indicate that the volcanic energy which resulted in the extrusion of the Mono craters is not yet entirely dissipated (pp. 285, 287, 292, 373).

478 —— Subaerial decay of rocks and origin of the red color of certain formations.

U. S. Geol. Surv., Bull. no. 52, pp. 65, 1889.

The hard and brackish quality of water in wells near trap dikes is noted (p. 17) and the action of percolating waters in the decay of rocks considered (p. 30).

479 **Russell** (Israel Cook). Correlation papers. The Newark system.
U. S. Geol. Surv., Bull. no. 85, pp. 344, 1892.
Gives shaft and boring sections at Carbon Hill and Midlothian, Virginia (p. 39).

480 —— A geological reconnoissance in central Washington.
U. S. Geol. Surv., Bull. no. 108, pp. 108, 1893.
The investigation was undertaken to determine the prospects for artesian waters. The paper describes the existing wells and the stratigraphy, structure, etc., affecting artesian prospects. The lavas beneath the clays are tilted and broken, and broad basins are impossible, although local basins in or above the basalt are described. The water beds are also tapped occasionally by drainage. Among the topics considered are flowing and deep wells (pp. 13, 39, 44), well sections (p. 56), fissures and faults in relation to springs and artesian wells (pp. 35, 40, 59), principles of artesian water (pp. 32–36), artesian prospects (pp. 39, 50, 63, 66), putrefaction by percolating waters (p. 47), location of test wells (p. 50), artesian water of Moxee Valley and its source (pp. 53–60), temperature of waters (p. 59), and waters of the John Day beds (p. 36).

481 —— A reconnoissance in southeastern Washington.
U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 4, pp. 96, 1897.
Discusses artesian principles (pp. 75–78) and local conditions (pp. 70, 78), and describes wells in basalt (pp. 49, 79–83), alluvium (p. 85), and the infiltration works at Walla Walla (p. 86). Concludes that the artesian area in Palouse region may be extended westward, but that successful wells are not likely in the uplands south of Snake River, and prospects are doubtful in the canyons. The conditions in the valley of the Walla Walla, however, are more favorable.

482 —— Water resources of a portion of southeastern Idaho.
U. S. Geol. Surv., 22d Ann. Rept., pt. 4, pp. 421–430, 1901.
Describes the physical characters of the region and notes the occurrence of large springs (p. 427). Discusses the occurrence of artesian waters between or beneath the deformed lava beds of the Snake River region (pp. 428–430).

483 —— Geology and water resources of Nez Perce County, Idaho. Part 1.
U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 53, pp. 85, 1901.
This paper is devoted mainly to the discussion of topography, geology, and soils. Wells are described on pages 15, 36, and 38, and springs on pages 20, 27, 33, 36, 38, 39, 80, and 81. The water capacity of the lava (p. 32) and the water sheets are mentioned in connection with the descriptions of the geologic formations, and the artesian areas are defined (pp. 35, 40–42). Solution basins are mentioned (pp. 83–84).

484 —— Geology and water resources of Nez Perce County, Idaho. Part 2.
U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 54, pp. 54–141, 1901.
Among the topics discussed are springs (pp. 96–97), horizontal wells (pp. 98–101), artesian well principles (pp. 101–104), artesian basins (pp. 104–115), methods of well construction (pp. 109–110, 115–119), bibliography of artesian waters (pp. 130–131), temperatures (pp. 106, 109), and regulation of flow (pp. 118–119).

485 **Russell** (Israel Cook). Geology and water resources of the Snake River plains of Idaho.

U. S. Geol. Surv., Bull. no. 199, pp. 192, 1902.

In addition to the geology the following topics are considered: (1) Springs, including spring conditions as represented by hillside, canyon, fissure, and cavern types (pp. 149–152, 162–171), together with their temperature and relation to geology (pp. 152–154); (2) artesian conditions (pp. 156–8); (3) surface, rock, and artesian wells, including records and temperature (pp. 173–178), imperfections of casing, etc. (p. 178); (4) The Lewis artesian basin (p. 178); (5) the Shoshone artesian slope (p. 180); (6) the flowing wells of the alluvium (p. 181); and the probable conditions beneath the eastern portion of the plains (p. 183). The full water supply is not yet developed, the streams not all being utilized. Wells are advised in Lewis and Shoshone basins and at "Hagerman bend," but great care should be taken to properly test each stratum and to see that the wells are properly cased (p. 184–185).

486 —— Preliminary report on artesian basins of southwestern Idaho and southeastern Oregon.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 78, pp. 53, 1903.

Discusses briefly the essential conditions (pp. 10–14) and surface indications (pp. 14–15) of artesian flows, and gives detailed descriptions of the wells and springs of the Lewis, Otis, Harney, and Whitehouse basins (pp. 24–44), and of wells in alluvium (pp. 44–45). The geology of the region (pp. 16–24), the proper size and casing of wells (pp. 45–47), and existing and proposed laws are also considered (pp. 47–49), and a bibliography of important papers on underground waters given (pp. 50–51).

487 —— Notes on the geology of southwestern Idaho and southeastern Oregon.

U. S. Geol. Surv., Bull. no. 217, pp. 83, 1903.

Describes common and hot springs and artesian wells, the waters of which are used for irrigation, baths, and heating purposes (pp. 23–24). The Lewis, Otis, Harney, and Whitehouse artesian basins are discussed, and their wells, prospects, and the relation of the water to petrology considered (pp. 25, 69–79).

488 —— Preliminary report on artesian basins in southwestern Idaho and southeastern Oregon.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 78, pp. 53, 1903.

The springs and wells, including the volume, temperature, and use of well water for irrigation are considered for the Lewis, Otis, Harney, and Whitehouse artesian basins (pp. 24–44). Special subjects discussed are artesian conditions (pp. 10–14), surface indications of water (pp. 14–15), geology of supplies (pp. 16–24), artesian wells in alluvium (pp. 44–45), well construction (pp. 45–46), necessity of records (pp. 46–47), needed laws (pp. 47–49), and literature relating to underground waters (pp. 50–51).

489 **Russell** (W. G.). Investigations in Kansas.
U. S. Geol. Surv., 2d Ann. Rept. Reclamation Service, 1902–3, pp. 326, 1904.
Describes two artesian wells at Meade, Kansas (p. 1327), and mentions springs in Cimarron River Valley.

S.

490 **Salisbury** (R. D.) **Chamberlin** (T. C.) and. Preliminary paper on the Driftless Area of the upper Mississippi Valley.
U. S. Geol. Surv., 6th Ann. Rept., pp. 199–322, 1885.
See Chamberlin (T. C.) and Salisbury (R. D.).

491. **Schmeckebier** (L. F.). Catalogue and index of the publications of the Hayden, King, Powell, and Wheeler Surveys.
U. S. Geol. Surv., Bull. no. 222, pp. 208, 1904.
The subject index includes entries of water analyses, artesian waters, artesian wells, springs, and other subjects relating to underground waters.

492. **Shaler** (Nathaniel S.). Report on the geology of Marthas Vineyard.
U. S. Geol. Surv., 7th Ann. Rept., pp. 297–363, 1888.
Mentions sulphur and chalybeate springs in the Tertiary clays at Gay Head and estimates that a flow of several thousand gallons per minute could be developed by proper methods.

493 —— The geology of Nantucket.
U. S. Geol. Surv., Bull. no. 53, pp. 55, 1889.
Mentions the springs near Polpis Harbor (p. 17) and notes the absorption of water by the gravels (pp. 14, 17, 19).

494 —— The origin and nature of soils.
U. S. Geol. Surv., 12th Ann. Rept., pt. 1, pp. 213–345, 1891.
Among the points discussed are: Relations of ground-water to soils (pp. 254–255), formation of caverns (p. 256), hot spring conditions (p. 258), rise of water by capillarity (p. 259), chemical character of ground water (pp. 260, 294), effect of variations of water level on soils (pp. 261, 341), crusts formed by the evaporation of ground water (p. 307), and contamination of well supplies (pp. 342).

495 —— The glacial brick clays of Rhode Island and southeastern Massachusetts: Origin and character of the clays.
U. S. Geol. Surv., 17th Ann. Rept., pt. 1, pp. 957–974, 1896.
Describes the mud springs or mud volcanoes in the clays and ascribes them to the escape of gases arising from the decay of buried vegetable matter (p. 971).

496 —— Geology of the Cape Cod district.
U. S. Geol. Surv., 18th Ann Rept., pt. 2, pp. 497–593, 1897.
Mentions or describes the springs near Woods Holl, and the wells of the outwash plains, especially those at Barnstable and Harwich (pp. 529–534).

497 **Shepard** (Edward M.). Missouri. [Wells and spring records.]

U. S Geol. Surv., Water Supply and Irrigation Paper no. 102, pp. 389–440, 1904.

Considers briefly the general underground water conditions (p. 389) and gives tables and notes on wells (pp. 390–416) and springs (pp. 416–440). The well data include depth, head, source, temperature, yield, quality (including analyses), records and uses; the spring data, temperature, quality (including analyses), yield, source, uses, etc.

498 **Shrader** (Frank C.). A reconnaissance of a part of Prince William Sound and the Copper River district, Alaska, in 1898.

U. S. Geol. Surv., 20th Ann. Rept., pt. 7, pp. 341–423, 1899.

Describes the occurrence at a Prince William Sound village of a spring containing sulphides of iron, cobalt, and possibly lead in solution, which caused much sickness and death and finally led to the removal of the village.

499 **Slichter** (Charles S.). Theoretical investigation of the motion of ground waters.

U. S. Geol. Surv., 19th Ann. Rept., pt. 2, pp. 295–384, 1897.

This paper is a technical discussion of the movements of ground water, including general laws (pp. 329–333), laws of rectilinear flow through soil (pp. 305–323), motion in horizontal planes (pp. 333–344), motion in vertical planes (pp. 351–358), and flow and interference of artesian wells in groups (pp. 358–380). A number of valuable tables and a bibliography are given.

500 —— The motions of underground waters.

U. S. Geol. Surv., Water Supply and Irrigation Paper no. 67, pp. 106, 1902.

The paper is a theoretical discussion, accompanied by records of experiments and tables. The following topics are considered: Amount of underground waters (pp. 13–15), permeability and porosity of rocks (pp. 15–17), cause and method of determining flow (pp. 17–30), underground drainage basins and shape of water table (pp. 31–38), chlorine method of measuring rate of underflow (pp. 46–48), electrical apparatus for determining underflow (pp. 48–51), deep water bearing zones, including Dakota and Potsdam horizons (pp. 52–60), recovery of water by wells and springs with discussions of contamination, variation of supply and of water table (pp. 61–73), use of collecting galleries and subsurface dams (pp. 73–78), and the capacity, measurement of flow, interference, and failure of artesian wells, with descriptions of the wells at Savannah, Georgia (pp. 79–102).

501 **Smith** (Eugene A.) and **Johnson** (Lawrence C.). Tertiary and Cretaceous strata of the Tuscaloosa, Tombigbee, and Alabama rivers.

U. S. Geol. Surv., Bull. no. 43, pp. 189, 1887.

Mentions or describes artesian borings at Bladen Springs, Alabama (pp. 17, 67), Livingston, Alabama (pp. 18, 84), and at Meridian, Mississippi (p. 17).

502 **Smith** (Eugene A.). Alabama. [Well records.]

U. S. Geol. Surv., Water Supply and Irrigation Paper no. 102, pp. 276–331, 1904.

Considers briefly the general underground water conditions and gives a large amount of well data, including records, source, head, yield, temperature, quality, analyses, uses, etc.

503 **Smith** (George Otis), **Tower** (George Warren) and. Geology and mining industry of the Tintic district, Utah.

See Tower (George Warren) and Smith (George Otis).

504 **Smith** (George Otis). Tintic Special folio, Utah. Geography and geology.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 65, pp. 1–4, 1900.

Notes the occurrence of springs and the underflow supplies of the mines and mills (p. 1).

505 —— Geology and water resources of a portion of Yakima County, Washington.

U. S. Geol. Surv., Water Supply and Irrigation Paper no. 55, pp. 68, 1901.

Gives detailed discussions of geology and geography (pp. 12–25) and considers the Atanum–Moxee, Wenas–Selah, Rye Grass Flat, Coweche Valley, and other artesian basins in more or less detail (pp. 40–48). The source (pp. 55–56) and conditions (pp. 37–39) of ground and artesian waters, their use for irrigation (pp. 53–54), the transfer movement between basins (p. 57), temperature (pp. 58–62), permanency of supply (p. 62), decrease of pressure (pp. 62–63), precautions to be observed (p. 63), and the occurrence of springs (pp. 43, 63) are also considered.

506 —— Ellensburg folio, Washington.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 86, pp. 7, 1903.

Discusses essential artesian conditions and describes the Atanum, Wide Hollow, and Moxee Valley artesian basins. Good but not unlimited supplies can probably be obtained. The deep wells, some of which are thermal, and the shallow wells, supplied by underflow from the streams, are considered, as is also the occurrence of springs throughout the quadrangle (pp. 6–7).

507 —— Mount Stuart folio, Washington.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 106, 10 pp., 1904.

Discusses the occurrence of ground water and springs (10. p).

508 **Smith** (H. L.), **Clements** (J. M.), and. Crystal Falls iron-bearing district of Michigan.

See Clements (J. M.), and Smith (H. L.)

509 **Smith** (William Sidney Tangier). A geological sketch of San Clemente Island, California.

U. S. Geol. Surv., 18th Ann. Rept., pt. 2, pp. 459–496, 1897.

Notes the occurrence of alkaline springs and mentions the penetration of sea water into wells (p. 465).

510 **Smith** (William Sidney Tangier). Lead and zinc deposits of the Joplin district, Missouri-Kansas.
U. S. Geol. Surv., Bull. no. 213, pp. 197–204, 1903.
Discusses the relation of the occurrence of ores to ground-water level and the part played by underground waters in ore deposition (pp. 200–203).

511 —— Lead, zinc, and fluorspar deposits of western Kentucky: The veins and vein minerals.
U. S. Geol. Surv., Bull. no. 213, pp. 210–213, 1903.
Notes the relation of ground water to the ores.

512 —— Hartville folio, Wyoming.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 91, p. 6, 1903.
Considers briefly the prospects for artesian wells (p. 1).

513 —— **Darton** (N. H.) and. Edgemont folio, South Dakota-Nebraska.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 108, pp. 10, 1904.
See Darton (N. H.) and Smith (W. S. Tangier).

514 **Smith** (William Sidney Tangier). Wells of Joplin [Missouri] and vicinity.
U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 102, pp. 404–408, 1904.
Gives records and analyses of waters.

515 **Smyth** (Henry Lloyd). The Marquette iron-bearing district of Michigan: The Republic trough.
U. S. Geol. Surv., Mon., vol. 28, pp. 525–553, 1897.
Ores are considered to be in part original and in part concentrated from carbonates by circulating waters with removal of silica (pp. 551–553).

516 **Spencer** (Arthur Coe). Geology of the Rico Mountains, Colorado: Erosion of Rico Dome and recent geological history.
U. S. Geol. Surv., 21st Ann. Rept., pt. 2, pp. 152–165, 1900.
Describes calcareous and ferruginous spring deposits and the occurrence of carbon dioxide and hydrogen sulphide gases (pp. 163–165).

517 —— The copper deposits of the Encampment district, Wyoming.
U. S. Geol. Surv., Prof. Paper no. 25, pp. 107, 1904.
Discusses the occurrence of ground waters in the mining district (pp. 44–45) and their relation to metamorphism (p. 36) and to ore deposition (pp. 44, 58–60, 69–70, 80–82).

518 **Spurr** (Josiah Edward). Economic geology of the Mercur mining district, Utah.
U. S. Geol. Surv., 16th Ann. Rept., pt. 2, pp. 343–455, 1896.
Discusses agency of hot waters and fumerolic gases in ore deposition (pp. 449–453, etc.).

519 **Spurr** (Josiah Edward). Geology of the Aspen mining district, Colorado, with atlas.

U. S. Geol. Surv., Mon., vol. 31, 260 pp. 1898.

Describes the solution and alteration of dolomites, etc., especially the Weber limestone, by percolating waters (pp. 24, 30–31) and discusses the action of ground water in the processes of dolomitization, silicification, and ferration (pp. 208–223). Ore deposition is ascribed to ascending heated waters (p. 232). An analysis of spring water is given (p. 213.)

520 —— Ore deposits of Monte Cristo, Utah.

U. S. Geol. Surv., 22d Ann. Rept., pt. 2, pp. 777–865, 1901.

Ascribes the ore deposition to circulating underground waters (p. 835), and describes the relation of ground-water level to ores (pp. 858–859). Many incidental references to the character of the solutions are given.

521 —— Ore deposits of Tonopah and neighboring districts, Nevada.

U. S. Geol. Surv., Bull. No. 213, pp. 81–87, 1903.

Describes hot springs near Silver Peak (p. 86).

522 —— Preliminary report on the ore deposits of Tonapah, Nevada.

U. S. Geol. Surv., Bull. no. 225, pp. 89–110, 1904.

Discusses relation of ore deposits to hot-spring action (p. 99), and notes the action of circulating ground waters on cementation (p. 105) and oxydation (p. 106).

523 **Stockton** (Fred). Timbered areas and water supply on headwaters of Henry Fork and Fall River [Idaho].

U. S. Geol. Surv., 2d Ann. Rept. Reclamation Service, 1902–3, pp. 291–295, 1904.

Describes character of springs of the district (p. 295).

524 **Stone** (George H.). The glacial gravels of Maine and their associated deposits.

U. S. Geol. Surv., Mon., vol. 34, 499 pp., 1899.

Discusses the transportation and erosion of fine material by subterranean streams and springs, the development of "gravel in till," and the erosion about springs (pp. 18–20). The method of erosion about springs is considered (pp. 64–67), and its importance in the development of valleys noted. The effect on ice sheets of springs beneath their base is discussed (pp. 305, 307).

525 **Stone** (Ralph W.). Oil and gas fields of eastern Greene County, Pennsylvania.

U. S. Geol. Surv., Bull. no. 225, pp. 396–412, 1904.

Discusses relation of water, oil, and gas (p. 407), and notes the occurrences of salt water in wells (pp. 410–412).

526 **Storrs** (H. A.). Electrical transmission of power for pumping.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 93, pp. 237–240, 1904.

Points out use of electric power for pumping from wells (p. 237).

527 **Storrs** (H. A.). Power development.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 93, pp. 311–314, 1904.

Considers ground water as a source of water for pumping for irrigation (pp. 313–314).

528 **Stout** (O. V. P.). Ground water at Kearney, Nebraska.

U. S. Geol. Surv., 21st Ann. Rept., pt. 4, pp. 216–217, 1900.

Discusses the peculiar variations of the wells, considering the influence of temperature, river level, direction of wind, barometric pressure, etc. No satisfactory explanation has been found for certain of the variations.

529 —— Reclamation and water storage in Nebraska.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 93, pp. 276–284, 1904.

Notes the extensive absorption of rain water in the sand-hill region of the North Platte (p. 283).

530 **Struthers** (Joseph). Salt [1901].

U. S. Geol. Surv., Min. Res. of U. S., 1901, pp. 853–866, 1902.

Gives production of salt from wells, springs, and other sources for the year 1901.

531 —— Bromine [1901].

U. S. Geol. Surv., Min. Res. of U. S., 1901, pp. 867–868, 1902.

Gives production of bromine as a by-product of brines, etc., for the year 1901.

532 —— Bromine.

U. S. Geol. Surv., Min. Res. of U. S., for 1902, pp. 897–898, 1904.

Describes briefly the occurrence of brines in Michigan.

533 **Sudworth** (George B.). Stanislaus and Lake Tahoe Forest Reserves, California and adjacent territory.

U. S. Geol. Surv., 21st Ann. Rept., pt. 5, pp. 499–561, 1900.

The failure of springs and wells at certain times is mentioned (p. 508).

534 **Swendsen** (G. L.). Investigations in Utah.

U. S. Geol. Surv., 2d Ann. Rept., Reclamation Service, 1902–3, pp. 450–486, 1904.

Mentions the occurrence of big springs in body of Bear Lake (p. 476).

T.

535 **Taylor** (Thomas U.). The Austin dam.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 40, pp. 52, 1900.

Notes the passage of a stream of water through the limestone beneath the dam, and quotes R. T. Hill on the local geology, including the occurrence of limestone cavities and the passage of water along the fault beneath the dam.

536 **Taylor** (Thomas U.). Irrigation systems of Texas.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 71, pp. 137, 1902.

This paper gives detailed descriptions of the Trans-Pecos, Pecos, Edwards Plateau, San Antonio, Nueces, Leona, Rio Grande and Colorado irrigation systems, with special attention to the systems used in the irrigation of rice. In connection with the discussion many large springs and deep-flowing and nonflowing wells are mentioned and described, especially those near San Antonio. Among the large springs are Tayah (p. 15), San Pedro (p. 19), Santa Rosa (p. 19), San Saba (p. 30), Connel (p. 40), and the springs of Big Bend River (pp. 19–21), Pecos Valley (p. 21), Edwards Plateau (p. 25), Del Rio (p. 25), Cienagas and Mud creeks (p. 27), Las Moras Creek (p. 29), Upper Nueces (p. 42), Kerr County (p. 42), Bailey Creek (p. 46), Kyac Creek (p. 46), South Llano River (p. 48), and vicinity of San Antonio (p. 52).

537 —— The water powers of Texas.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 105, pp. 116, 1904.

Considers the artesian wells at San Antonio (pp. 23–25) and describes in some detail with illustrations the numerous large springs giving rise to the streams. Their use for irrigation and power is also considered and measurements of flow given.

538 **Todd** (James Edward). The moraines of the Missouri Coteau and their attendant deposits.

U. S. Geol. Surv., Bull. no. 144, pp. 71, 1896.

Notes the valuable springs of the Koto Hills (p. 20), and the spring and traverture deposits of the Pierre formation (p. 56). A number of well records, mainly shallow, are given (pp. 58–61).

539 —— The moraines of southeastern South Dakota and their attendant deposits.

U. S. Geol. Surv., Bull. no. 158, pp. 171, 1899.

Describes copious springs of Jerauld County and considers the source of the water, the effect of decomposing pyrite on its character, and its association with landslides (pp. 19–21). The flowing wells from the gravels near Diana and Forrestburg and from the Dakota formation are discussed (p. 125). A considerable number of well records, mainly shallow, are given (pp. 49–51, 73, 74, 120).

540 —— Geology and water resources of a portion of southeastern South Dakota.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 34, pp. 34, 1900.

Gives a map showing depth of artesian water and describes the waters from the stream deposits, drift, and Dakota sandstone. The pressure and variations of wells through interference, barometric pressure, difference in depths of supplies, leakage, etc., are considered and hints relating to well construction and the securing of permanent supplies are given (pp. 26–31). A number of springs are noted (pp. 23, 24, 26).

541 **Todd** (James Edward). Olivet folio, South Dakota.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 96, 1903.

Gives a number of well sections (pp. 1–2) and considers surface waters, springs, and underground waters, including waters of the drift (pp. 4–5). The artesian supplies of the Niobrara and Dakota formations, artesian pressure and its fluctuation, variations due to temperature, barometric pressure, and leakage, amount of flow, future prospects, and methods of well construction are also treated (pp. 5–6). Maps showing depths of drift, flowing areas of Pleistocene formations, areas of flowing and nonflowing rock wells, contours of water surface, etc., are given.

542 —— Parker folio, South Dakota.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 97, pp. 6, 1903.

Gives well sections (pp. 1–2). Describes surface waters, including streams, springs, and lakes (p. 4), and subterranean waters (pp. 4–5). Under the latter heading shallow wells, tubular wells, wells of the drift and Dakota sandstone, and supplies of Dakota waters, including flow, quality, pressure, and decline are considered. A map showing depths of the drift and a map giving areas of Pleistocene flows, of areas of flowing and nonflowing Dakota water, and contours of water surface are included.

543 —— Mitchell folio, South Dakota.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 99, pp. 7, 1903.

Gives several well sections (pp. 2–3) and describes surface and underground waters, including those reached by shallow and tubular wells. The amount, quality, pressure, and decline of artesian water is considered, and maps showing depths of drift, depths of Sioux quartzite, areas of flows from the drift and from Benton and Dakota formations, and contours of the Sioux quartzite and of artesian head are given.

544 —— and **Hall** (C. M.). Alexandria folio, South Dakota.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 100, pp. 6, 1903.

Gives artesian well sections (p. 2). Considers surface waters, streams, springs, shallow and tubular wells, wells of Benton and Dakota formations, and flow, quality, and pressure of the waters (pp. 4–6). A drift map giving data in regard to shallow wells, a map showing depths to the Sioux quartzite, and a map showing Pleistocene, Benton, and Dakota areas of flowing wells, of Dakota pumping wells, and contours showing head of water are also given.

545 —— and **Hall** (C. M.). Geology and water resources of part of the lower James River Valley, South Dakota.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 90, pp. 47, 1904.

Describes the Dakota (pp. 14–18), Benton (pp. 18–19), and Niobrara (p. 20) water horizons, and gives a large number of well and other records (pp. 11, 15–17, pls. 8–21). Springs (pp. 35–36), shallow and pump wells (pp. 36–39), flowing wells (pp. 39–43), decline in pressure (pp. 42–43), and waste of water (p. 43), are discussed. Maps showing the geology, depth of Dakota sandstone, depth of drift, bed-rock contours, and of flowing and nonflowing areas accompany the paper.

546 **Todd** (James E.). Well records in Lyon County, Minnesota.
U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 102, p. 481, 1904.
Gives table of records, including depth, head, quality, and yield.

547 —— Huron folio, South Dakota.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 113, pp. 6, 1904.
Discusses occurrence of underground waters, springs, and shallow, tubular, and artesian wells (pp. 4–5). Waters are obtained from the drift, Pierre clay, and Benton and Dakota sandstones. A section showing the occurrence of artesian waters, sketch maps showing thickness of drift and depth of Sioux quartzite, and an artesian water-map showing flowing Dakota and drift areas, and the contours of the Sioux quartzite or of the granite are given.

548 **Tower** (George Warren), **Emmons** (Samuel Franklin) and. Butte special folio, Montana.
See Emmons (Samuel Franklin) and Tower (George Warren).

549 —— and **Smith** (George Otis). Geology and mining industry of the Tintic district, Utah.
U. S. Geol. Surv., 19th Ann. Rept., pt. 3, pp. 601–767, 1898.
Considers the springs of the district, the relation of the mines to ground water, and the water supply furnished by wells in alluvium. In the limestone, fissures conduct water to the syncline, mines in the higher portions of the limestone being dry. Water in monzonite does not penetrate so deeply as in limestone (p. 612). The supplies of the mills are from wells (p. 614). The ores, both in the sedimentary and igneous rock, were deposited by circulating alkaline sulphide solutions with temperatures of 200° (pp. 714–715). Alteration of ore deposits by vadose waters is considered (p. 719).

550 **Tucker** (Frederick de L. Booth). Colonization.
U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 93, pp. 122–126, 1904.
Notes utilization of underflow for irrigation in India (p. 122).

551 **Turner** (H. W.). Jackson folio, California.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 11, pp. 6, 1894.
Describes caves with stalactites (p. 3) and notes a number of deep borings (p. 4).

552 —— and **Lindgren** (Waldemar). Marysville folio, California.
See Lindgren (Waldemar) and Turner. (H. W.).

553 —— Downieville folio, California.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 37, pp. 8, 1897.
Describes the occurrence of warm springs along the fissures of the earthquake of 1876, and mentions the Sulphur Spring resort and the artesian wells of the west side of the Sierra Valley (p. 8).

554 —— and **Ransome** (F. L.). Sonora folio, California.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 41, pp. 7, 1897.
Notes the occurrence of solution caverns in the limestone of the Calaveras formation (p. 2).

555 **Turner** (H. W.), and **Ransome** (F. L.). Big Trees folio, California.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 51, pp. 8, 1898.
Notes the formation of salt by the evaporation of water seeping through rock into glacial pot holes (p. 7).

U.

556 **Udden** (J. A.). On account of the Paleozoic rocks explored by deep borings at Rock Island, Illinois, and vicinity.
U. S. Geol. Surv., 17th Ann. Rept., pt. 2, pp. 829–849, 1896.
Includes descriptions of wells in Devonian limestone, Niagara limestone, Hudson River shales, Galena limestone, Trenton limestone, St. Peters sandstone, Lower Magnesian limestone, and Potsdam formation.

557 **Ulrich** (Edward O.). Lead, zinc, and fluor spar deposits of western Kentucky. Geology and general relations.
U. S. Geol. Surv., Bull. no. 213, pp. 205–210, 1903.
Notes the occurrence of channels of underground waters along fracture lines (p. 210).

558 —— **Hayes** (C. Willard) and. Columbia folio, Tennessee.
See Hayes (C. Willard) and Ulrich (Edward O.).

559 **Upham** (Warren). The upper beaches and deltas of the Glacial Lake Agassiz.
U. S. Geol. Surv., Bull. no. 39, pp. 84, 1887.
Contains references to a considerable number of wells, mainly shallow, giving information relating to glacial deposits.

560 —— The Glacial Lake Agassiz.
U. S. Geol. Surv., Mon., vol. 25, 658 pp., 1895.
Discusses the common and artesian wells of the Red River Valley (pp. 523–581), considering the sources of fresh, alkaline, and saline waters, the use of water for irrigation, and the waters of the Dakota sandstone. The wells in Minnesota, North Dakota, and Manitoba are described. There are also a large number of incidental references to wells, brines, the Dakota sandstone, and springs, many of which are noted in the index. The occurrence of gases in water is mentioned (pp. 553–569)

V.

561 **Van Hise** (Charles Richard). Principles of pre-Cambrian North American geology.
U. S. Geol. Surv., 16th Ann. Rept., pt. 1, pp. 571–874, 1896.
Notes the closing of physical pores in rocks by pressure below depths of 10,000 meters, but states that rock-inclosed liquid-filled cavities can exist at an indefinite depth, or at least to a depth where the liquid and rock are miscible in all proportions (pp. 589–593).

562 —— The Marquette iron-bearing district of Michigan. Lower Marquette series.
U. S. Geol. Surv., Mon., vol. 28, pp. 221–407, 1897.
The iron ores are regarded as in part original and in part derived through secondary enrichment by downward moving waters of lean, cherty carbonate of lime, the silica being removed (pp. 401–405).

563 **Van Hise** (Charles Richard), **Leith** (C. K.), and **Clements** (J. Morgan). Iron-ore deposits of Lake Superior region.

U. S. Geol. Surv., 21st Ann. Rept., pt. 3, pp. 305–434, 1900.

The accumulation of the Lake Superior iron ores is attributed to descending underground waters (pp. 226–228, 323, 419), the action of water in the ore accumulation in the different ranges being considered, as follows: Penokee-Gogebic (pp. 348–351), Mesabe (pp. 367–369), Marquette (pp. 381–383), Menominee (pp. 396–400), and Vermilion (pp. 407–408).

564 **Van Hise** (C. R.). Preliminary report on the lead and zinc deposits of the Ozark region. Introduction.

U. S. Geol. Surv., 22d Ann. Rept., pt. 2, pp. 33–60, 1901.

Ascribes the segregation of zinc in the Silurian limestones of the Mississippi Valley and in Missouri and Arkansas to artesian circulation, deposition taking place in crevices, joints, and cavities. The nature of the solutions is discussed.

565 —— A treatise on metamorphism.

U. S. Geol. Surv., Mon., vol. 47, pp. 1286, 1904.

In this elaborate treatise, ground waters and their part in metamorphism are considered at great length. The crust is divided into two great zones according to nature of metamorphism, the first known as the zone of katamorphism and the second as the zone of anamorphism. The zone of katamorphism is further divided into an upper belt of weathering and a lower belt of cementation. Among the special points considered are (1) rock openings, including bedding planes, joints, faults, fissility, spaces in fragmental rocks, and openings in lavas; (2) waters of the belt of weathering, including a discussion of the water table, amount and source of water circulation, and fluctuations depending on barometric pressure, temperature, precipitation, seepage, evaporation, uplift, subsidence, influence of man, etc.; (3) waters of the belt of cementation, including circulation, temperature, and work; (4) waters of the zone of anamorphism, including quality, circulation, limits of depth, and work; (5) the part of water in ore formation; and (6) source of subterranean gasses associated with waters. The portions bearing on the circulation are especially pertinent.

566 **Vaughan** (Thomas Wayland) **Hill** (Robert T.) and. Nueces folio, Texas.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 42, pp. 4, 1898.

See Hill (Robert T.) and Vaughan (T. Wayland).

567 —— Geology of the Edwards Plateau and Rio Grande Plain adjacent to Austin and San Antonio, Texas, with reference to the occurrence of underground water.

See Hill (Robert T.) and Vaughan (T. Wayland).

568 **Vaughan** (Thomas Wayland). Reconnaissance in the Rio Grande coal fields of Texas.

U. S. Geol. Surv., Bull. no. 164, pp. 100, 1900.

Notes the relation of the San Felipe Spring to joints (p. 16). Describes or gives section of artesian wells or borings at Santo Tomas, Carrizo Springs, and near the Rio Grande (pp. 25, 37, 41–44, 50–51). The Carrizo sand as a source of water is mentioned (p. 37).

569 **Vaughan** (Thomas Wayland). Uvalde folio, Texas.

U. S. Geol. Surv., Geol. Atlas of U. S. folio, pp. 7, no. 64, 1900.

Mentions the caves of the Edwards limestone (p. 1) and describes the numerous springs at the base of the Leona formation. The waters are used for irrigation. The springs are not associated with faults (p. 6). There are at present no artesian wells, but artesian water may possibly be found in the Glen Rose formation, but the absence of springs makes this seem improbable. The wells in the surficial deposits, basalt, and in the sedimentary formations including the Glen Rose, Edwards, and Myrick are discussed (pp. 5–6).

570 —— **Hill** (Robert T.) and. Austin folio, Texas.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 76, pp. 8, 1902.

See Hill (Robert T.) and Vaughan (T. Wayland).

W.

571 **Walcott** (Charles Doolittle). Administrative report [1893–94].

U. S. Geol. Surv., 15th Ann. Rept., pp. 129–144, 1895.

Mentions work of G. K. Gilbert on artesian waters of Pueblo quadrangle of Colorado (p. 136).

572 —— Report of the Director [1894–95].

U. S. Geol. Surv., 16th Ann. Rept., pt. 1, pp. 1–130, 1896.

Notes the work of N. H. Darton on artesian prospects of the Atlantic Coastal Plain (p. 23); of Frank Leverett on the water supply of the drift; of R. T. Hill on the artesian waters of Texas (pp. 27, 48); of Lawson on those of San Francisco Bay, and of F. H. Newell on artesian wells in general (p. 45). Investigations of artesian waters and springs in the Nepesta and Apeshapa quadrangles, Colorado (p. 25–26) and in the deep wells of North Dakota (p. 48) are also mentioned. The laws governing artesian investigations are quoted (p. 43), and the measurement of springs in Texas mentioned (p. 48). The output of mineral waters is given as 21,569,608 gallons, with a value of $3,741,846.

573 —— Report of the Director [1895–96].

U. S. Geol. Surv., 17th Ann. Rept., pt. 1, pp. 1–200, 1896.

Notes the results of work by G. K. Gilbert on artesian waters and underflow of the Arkansas Basin and Pueblo and Apeshapa sheets in Colorado (pp. 32, 74, 80), of R. T. Hill on the underground waters of Texas (pp. 35, 36, 80), of N. H. Darton on those of North and South Dakota (pp. 37, 73, 80), of A. C. Lawson in California (p. 48), of Frank Leverett in Illinois, and of E. H. Barbour in Nebraska (p. 73). The general work of the Division of Hydrography on underground waters is described (pp. 70–71) and an analysis of a boring sample from well at Key West, Florida, made by the chemical department, noted (p. 70). The product of mineral waters is given as 21,463,543 gallons, with a value of $4,254,237.

574 —— Report of the Director [1896–97].

U. S. Geol. Surv., 18th Ann. Rept., pt. 1, pp. 1–130, 1897.

Gives allotment for artesian work (p. 20) and describes work on artesian and other underground waters by N. H. Darton in District of Columbia, Maryland, and Virginia (p. 32), in South Dakota and Nebraska (p. 73), by T. W. Vaughan in Texas (pp. 36, 75), R. T. Hill in Texas (pp. 37, 75), R. C. Hills in Colorado (p. 40), Frank Leverett in

Ohio and Indiana (pp. 55, 57, 72), A. C. Lane in Michigan (p. 72), E. J Babcock in North Dakota (p. 73), E. H. Barbour in Nebraska (p. 74), and Erasmus Haworth and W. D. Johnson in Kansas (p. 74). The work of William Hullock on temperatures of the mile-deep well near Pittsburg (p. 60) and of E. C. Murphy and O. P. Hood on windmills and pumps is also mentioned (p. 74). A summary of the work of the Division of Hydrography on artesian problems (pp. 70–71), and statistics of wells in the Mississippi Valley are given. The product of mineral waters for 1895 is stated as 25,795,312 gallons, with a value of $4,136,192.

575 **Walcott** (Charles Doolittle). Report of the Director [1897–98].

U. S. Geol. Surv., 19th Ann. Rept., pt. 1, pp. 1–143, 1898.

Describes the work of N. H. Darton and F. H. Ainsworth on well temperatures in western Nebraska; of R. T. Hill in the underground waters of Black and Grand Prairies, Edwards Plateau, and Rio Grande Plain in Texas, and of the Division of Hydrography on general underground investigations. The relation of ground water level to the oxidation of ores in the Tintic district is mentioned. The product of mineral waters for 1897 is stated as 23,255,911 gallons, with a value of $4,599,106.

576 —— Report of the Director [1898–99].

U. S. Geol. Surv., 20th Ann. Rept., pt. 1, pp. 11–209, 1899.

Describes work on underground waters by N. H. Darton in District of Columbia, Maryland, Virginia, South Dakota, and Texas; of R. C. Hills in Colorado, of Frank Leverett in Indiana, of A. C. Lane in Michigan, and of E. J. Babcock in North Dakota. The product of mineral waters for 1898 is given as 28,853,467 gallons, with a value of $8,051,833. (See index of report.)

577 —— Report of the Director [1899–1900].

U. S. Geol. Surv., 21st Ann. Rept., pt. 1, pp. 11–204, 1900.

Gives a summary of publications of the Survey relating to artesian waters, 1879–1900 (pp. 31–32), and mentions the work of the division of Hydrography on underground waters (p. 43). The allotment for such work is stated (p. 64). The work of N. H. Darton, C. C. O'Harra, and J. E. Todd on the underground waters of the Great Plains and Black Hills; of N. H. Darton in South Dakota and Wyoming; of R. T. Hill in the Black and Grand Prairies, Texas; of W. H. Weed on the Boulder Hot Springs of Montana, of W. A. Setchell on plant life of hydro-thermal waters of the Yellowstone National Park (p. 80), and of C. M. Hall in South Dakota, is reviewed. The output of mineral waters for 1899 is given as 39,562,136 gallons, with a value of $6,948,030.

578 —— Report of the Director [1900–1901].

U. S. Geol. Surv., 22nd Ann. Rept., pt. 1, pp. 3–207, 1901.

Describes work on underground waters, by Frank Leverett, in Michigan; N. H. Darton, W. S. T. Smith, J. E. Todd, C. M. Hall, E. H. Barbour, and C. C. O'Harra in the region including North Dakota, South Dakota, Colorado, Kansas, Nebraska, and Wyoming; and G. O. Smith and F. C. Calkins in Washington; I. C. Russell in Idaho; C. S. Slichter (underflow measurements) in the Mississippi Valley. Also notes work of William Hallock on the physics of geysers, and of N. H. Darton on deep wells and their relation to health. The product of mineral waters for 1900 is given as 47,558,784, with a value of $6,245,172. (See index of report).

578a **Walcott** (Charles Doolittle). Report of the Director [1901–1902].

U. S. Geol. Surv., 23rd Ann. Rept., pp. 206, 1902.

Notes the work on underground waters, by N. H. Darton, in Arizona; J. E. Todd, in the James River Valley, in South Dakota; of C. M. Hall in the Red River Valley, and of N. H. Darton on the Great Plains and Black Hills (pp. 40–41). The work of N. H. Darton on deep well records and underground temperatures (p. 41), of C. S. Slichter on movements of water in sands and gravel (p. 101), of Arnold Hague and William Hallock on geysers and hot spring phenomena of the Yellowstone National Park (p. 46), and of W. H. Weed on the Hot Springs of Arkansas (p. 62) is also mentioned. A list of survey publications of the year relating to underground and surface waters is given (pp. 118–119). The production of mineral waters for 1901 is given as 55,771,188 gallons, valued at $7,586,962.

579 —— Letter of transmittal: First Annual Report of the Reclamation Service, June 17 to December 1, 1902.

U. S. Geol. Surv., 1st. Ann. Rept. Reclamation Service, 1902, pp. 12–14, 1903.

Mentions deep well problems in western Kansas, western Nebraska, and in central Oregon (p. 13).

580 —— Report of the Director [1902–1903].

U. S. Geol. Surv., 24th Ann. Rept., pp. 302, 1904.

Gives an account of the organization of the Division of Hydrology and the scope of its work (pp. 180, 196–213), and of the Hydro-Economic Division (pp. 213–214). The production of mineral waters for 1902 is stated as 64,859,451 gallons, with a value of $8,793,761. Work in the following States is described: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Georgia, Florida, Minnesota, Wisconsin, Michigan, Iowa, Missouri, Arkansas, Louisiana, Kentucky, Tennessee, Mississippi, Alabama, Arizona, California, Colorado, Idaho, Kansas, Nebraska, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Washington, and Wyoming. Details of the work of the following men on underground waters are also given: N. H. Darton, M. L. Fuller, Arnold Hague, Waldmar Lindgren, I. C. Russell, W. C. Alden, W. S. Bayley, J. M. Boutwell, G. H. Perkins, W. O. Crosby, Laurence La Forge, H. E. Gregory, A. C. Veatch, C. S. Slichter, F. B. Weeks, G. N. Knapp, S. W. McCallie, C. W. Hall, A. R. Shultz, W. F. Cooper, W. H. Norton, E. M. Shepard, A. H. Purdue, L. C. Glenn, E. A. Smith, L. C. Johnson, G. B. Richardson, W. C. Mendenhall, W. T. Lee, C. A. Fisher, Homer Hamlin, G. E. Condra, C. M. Hall, D. E. Willard, C. N. Gould, I. C. Russell, J. E. Todd, and C. C. O'Harra. Investigations on the measurement of underflow, by C. S. Slichter, on the water supplies of Molokai, Hawaiian Islands, by W. Lindgren, and on the question of diminution of geyser action in the Yellowstone National Park, are also noted.

581 **Warman** (Philip Creveling). Bibliography and index of the publications of the United States Geological Survey, with the laws governing their printing and distribution.

U. S. Geol. Surv., Bull. no. 100, pp. 495, 1893.

Gives list of Survey publications to date of issue, with tables of contents. The index contains references to most of the more important discussions or descriptions relating to underground waters.

582 **Warman** (Philip Creveling). Catalogue and index of the publications of the United States Geological Survey, 1880–1901.
U. S. Geol. Surv., Bull. no. 177, pp. 858, 1901.
Gives lists of the Survey publications, with tables of contents of some. Has an extended index containing references to a large number of descriptions or discussions bearing on underground waters.

583 —— Catalogue and index of publications of the United States Geological Survey, 1901–1903.
U. S. Geol. Surv., Bull. no. 215, pp. 234, 1903.
Brings the list of publications and index of Survey papers to date, being supplementary to Bulletins 100 and 177.

584 **Weed** (Walter Harvey). Formation of travertine and siliceous sinter by the vegetation of hot springs.
U. S. Geol. Surv., 9th Ann. Rept., pp. 613–676, 1889.
Among the subjects discussed are the following: Vegetable growth in hot springs (pp. 620–628), the Mammoth Hot Springs and the waters of the Upper Geyser Basin of Fire Hole River, vegetable and chemical ingredients of the water, form, composition (with analyses), weathering, etc., of the travertine deposits, and analyses of hot-spring waters and of siliceous sinter. Concludes that plant life of Mammoth Hot Springs causes deposition of travertine, and that vegetation of hot alkaline waters of Geyser Basin eliminates silica from the water by the vital growth and produces deposition of siliceous sinter. The same principles probably apply to the sinters of Steamboat Springs, Nevada, in the Azores, and possibly in Iceland and New Zealand.

585 —— **Iddings** (Joseph P.) and. Livingston folio, Montana.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 1, pp. 4, 1894.
See Iddings (Joseph P.) and Weed (Walter H.).

586 —— and **Pirsson** (Louis Valentine). Geology of the Castle Mountain mining district, Montana.
U. S. Geol. Surv., Bull. no. 139, pp. 104, 1896.
Notes the occurrence of springs and the disappearance of streams into gravel and limestone (p. 20). Describes caves and abandoned subterranean channels in the carboniferous limestone (p. 40). The White Sulphur Hot Springs, temperature 125°, from the Miocene lake beds, is also discussed. The heat is supposed to be from igneous intrusions. Flow, 1,300 gallons per hour. Spring is surrounded by sulphur deposits. Hotels and a park have been built (pp. 150–151).

587 —— Yellowstone National Park folio. Sedimentary rocks.
U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 30, pp. 4–5, 1896.
Describes calcareous deposits of hot springs and the formation of siliceous sinter through agency of algous life. Mentions the leaching, etc., by solfataric springs giving rise to the "paint pots."

588 —— and **Pirsson** (L. V.). Geology and mineral resources of the Judith Mountains of Montana.
U. S. Geol. Surv., 18th Ann. Rept., pt. 3, pp. 437–616, 1897.
Notes the common occurrence of springs, including large and powerful ones in shale and limestones, some of which give rise to large streams at once (pp. 447, 452–454). The springs of the Benton shale (p. 513) and

of the Cretaceous beds (p. 525) are described. The occurrence of underground drainage (p. 529) and of deposits of limonite formed by waters from the porphyry (p. 152) are noted. The ores, both original and replacement, are supposed to have been deposited by ascending waters and vapors through limestone or along faults (pp. 594–596).

589 **Weed** (Walter Harvey). Siliceous sinter. The educational series of rock specimens collected and distributed by the United States Geological Survey.

U. S. Geol. Surv., Bull. no. 150, pp. 91–93, 1898.

Describes character and method of formation through algous agency of siliceous sinter from the Yellowstone National Park, and gives an analysis.

590 —— Traverture. The educational series of rock specimens collected and distributed by the United States Geological Survey.

U. S. Geol. Surv., Bull. no. 150, pp. 99–101, 1898.

Explains origin and gives analysis of traverture from the Yellowstone National Park.

591 —— Geology of the Little Belt Mountains, Montana.

U. S. Geol. Surv., 20th Ann. Rept., pt. 3, pp. 257–461, 1899.

Mentions the interrupted streams of the limestone areas (p. 275), the springs of Judith region (p. 311), and notes the ascending hot carbonated and sulphide waters of the Neihart district (pp. 420–423).

592 —— **Hague**, Arnold [and]. Descriptive geology of Huckleberry Mountain and Big Game Ridge: Snake River, Hot Springs.

U. S. Geol. Surv., Mon., vol. 32, pt. 2, pp. 177–178, 1899.

See Hague (Arnold), [and Weed (W. H.)].

593 **Weed** (Walter Harvey). Fort Benton folio, Montana.

U. S. Geol. Surv., Geol. Atlas of U. S. folio no. 55, pp. 7, 1899.

Notes the passage of Belt Creek through local underground passages (p. 1). States that the rocks underlying the flat areas between the mountains would probably afford artesian waters. The surface supply is insufficient (p. 6).

594 —— Little Belt Mountains folio, Montana.

U. S. Geol. Surv., Geol. Atlas of U. S., folio no. 56, pp. 9, 1899.

Streams are reported dry in summer because of absorption into underground passages of the limestones. Describes the White Sulpnur group of 9 springs. The water is warm and has medicinal properties, being used at the near-by hotels and baths. An analysis is given (p. 8).

595 —— Mineral vein formation at Boulder Hot Springs, Montana.

U. S. Geol. Surv., 21st Ann. Rept., pt. 2, pp. 227–255, 1900.

Describes ore deposition at Steamboat Springs, Nevada, and Sulphur Bank, California. Boulder Hot Springs are now depositing both vein and surface deposits, including some gold and silver (pp. 233–235). The waters have a temperature up to 164° and have altered the adjacent granites, but although algæ are present little silica is deposited (p. 237). Surface waters penetrated to heated rhyolite intrusions and on rising the dissolved minerals were deposited by cooling and release of pressure (pp. 249–251).

596 **Weed** (Walter Harvey). Ore deposits at Butte, Montana.
U. S. Geol. Surv., Bull. no. 213, pp. 170–180, 1903.
Ascribes ore deposition to hot solutions ascending along fractures in the granite (p. 177).

597 —— Gypsum deposits in Montana.
U. S. Geol. Surv., Bull. no. 223, pp. 74–75, 1904.
Notes the presence of gypsum in hot spring waters and the deposition of gypsum and stilbite in old hot spring fissures.

598 —— Notes on the copper mines of Vermont.
U. S. Geol. Surv., Bull. no. 225, pp. 190–199, 1904.
Discusses the limits of ground waters in certain of the mines (p. 192).

599 **Weeks** (Fred Boughton). Bibliography and index of North American geology, paleontology, petrology, and mineralogy for 1802 and 1893.
U. S. Geol. Surv., Bull. no. 130, pp. 210, 1896.
Artesian wells are listed under "Economic products described."

600 —— Bibliography and index of North American geology, paleontology, petrology, and mineralogy for the year 1894.
U. S. Geol. Surv., Bull. no. 135, pp. 141, 1896.
Artesian wells are listed under "Economic products described."

601 —— Bibliography and index of North American geology, paleontology, petrology, and mineralogy for 1895.
U. S. Geol. Surv., Bull. no. 146, pp. 130, 1896.
Artesian wells and water supply are listed under "economic products described."

602 —— Bibliography and index of North American geology, paleontology, petrology, and mineralogy for 1896.
U. S. Geol. Surv., Bull. no. 149, pp. 152, 1897.
Artesian wells, mineral water, and water supply are listed under "economic products described."

603 —— Bibliography and index of North American geology, paleontology, petrology, and mineralogy for 1897.
U. S. Geol. Surv., Bull. no. 156, pp. 130, 1898.
Water analyses are listed under "chemical analyses," and artesian water, artesian wells, and water supplies under "economic products described."

604 —— Bibliography and index of North American geology, paleontology, petrology, and mineralogy for 1898.
U. S. Geol. Surv., Bull. no. 162, pp. 163, 1899.
Artesian water, artesian wells, and water supply are listed under "economic products described."

605 —— Bibliography and index of North American geology, paleontology, petrology, and mineralogy for the year 1895.
U. S. Geol. Surv., Bull. no. 172, pp. 146, 1900.
Artesian water, artesian wells, mineral waters, and water supply are listed under "economic products described," while analyses are listed under "chemical analyses."

606 **Weeks** (Fred Boughton). Bibliography of North American geology, paleontology, petrology, and mineralogy for the years 1892–1900, inclusive.

U. S. Geol. Surv., Bull. no. 188, pp. 717, 1902.

Papers relating to underground waters and springs are catalogued under authors.

607 —— Index to North American geology, paleontology, petrology, and mineralogy for the years 1892–1900, inclusive.

U. S. Geol. Surv., Bull. no. 189, pp. 337, 1902.

Artesian water, artesian wells, mineral water, and water supply are listed under "economic products described," while analyses are listed under "chemical analyses."

608 —— Bibliography and index of North American geology, paleontology, petrology, and mineralogy for the year 1901.

U. S. Geol. Surv., Bull. no. 203, pp. 144, 1902.

Artesian water, artesian wells, and water supply are listed under "economic products described."

609 —— Bibliography and index of North American geology, paleontology, petrology, and mineralogy for the year 1902.

U. S. Geol. Surv., Bull. no. 221, 200 pp., 1903.

Papers relating to underground waters are listed under "economic products described" and under "chemical analyses."

610 —— New York. [Well and spring records.]

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 102, pp. 169–206, 1904.

Discusses the general underground water conditions (pp. 169–171) and gives tables and notes relating to wells (pp. 172–198) and springs (pp. 199–206). The well data include source, temperature, yield, quality, use, records, and analyses; the spring data temperature, quality, yield, source, and uses.

611 —— Bibliography and index of North American geology, paleontology, petrology, and mineralogy for the year 1903.

U. S. Geol. Surv., Bull. no. 240, 243 pp. 1904.

Waters are more carefully indexed than in preceding volumes, being listed under "chemical analyses," "economic products described," etc.

612 **Whistler** (John T.). Investigations in Oregon.

U. S. Geol. Surv., 2d Ann. Rept. Reclamation Service, 1902–3, pp. 433–440, 1904.

Notes occurrence of large springs, some thermal, at Bonanza (p. 439).

613 **White** (Charles A.). Correlation Papers. Cretaceous.

U. S. Geol. Surv., Bull. no. 82, pp. 273, 1891.

Discusses artesian water of the Dakota formation (p. 171) and refers to wells or gives records of borings in New Jersey (p. 79) Virginia (p. 90) and elsewhere.

614 **White** (Israel C.). Stratigraphy of the bituminous coal field of Pennsylvania, Ohio, and West Virginia.

U. S. Geol. Surv., Bull. no. 65, pp. 212, 1891.

Gives several sections made up in whole or in part of well borings.

615 **Whitfield** (James Edward), **Gooch** (Frank Austin) and. Analysis of waters of the Yellowstone National Park with an account of the methods of analysis employed.

U. S. Geol. Surv., Bull. no. 47, pp. 84, 1888.

See Gooch (Frank Austin) and Whitfield (James Edward).

616 [**Williams**, J. Albert]. Salt.

U. S. Geol. Surv., Min. Res., 1882, pp. 532–553, 1883.

Gives the number, average depth, and strength of brines of wells of different States (p. 532), with more specific references on subsequent pages to the salt wells of Michigan, New York, West Virginia, Ohio, etc., and to the saline springs of New York, Montana, Dakota, Colorado, Pacific coast, Nevada, California, Oregon, Idaho, and Arizona (pp. 535–550).

617 —— Sulphur.

U. S. Geol. Surv., Min. Res., 1882, pp. 578–579, 1883.

Mentions sulphur springs of the Rocky Mountains.

618 —— Administrative report [1884–85].

U. S. Geol. Surv., 6th Ann. Rept., pp. 88–93, 1885.

In a summary of mineral products of the United States the outputs of mineral waters for 1883 and 1884 are given as 47,289,743 and 68,720,936 gallons, with values of $1,139,483 and $1,665,490, respectively.

619 —— Salt.

U. S. Geol. Surv., Min. Res., 1883–84, pp. 827–850, 1885.

Gives more or less descriptive matter relating to the salt wells or borings of Michigan, New York, Ohio, Virginia, Illinois, Indiana, Kentucky, Tennessee, Kansas, California, and Nebraska, and to saline springs of New York, Illinois, Indiana, Kentucky, Tennessee, Kansas, Nebraska, Montana, South Dakota, and Colorado.

620 —— Administrative report [1885–86].

U. S. Geol. Surv., 7th Ann. Rept., pp. 130–134, 1888.

Gives the product of mineral waters for 1885 as 9,148,401 gallons, with a value of $1,312,845. The decrease is due to the exclusion of certain Wisconsin artesian wells.

621 **Wilson** (Herbert M.). Irrigation in India.

U. S. Geol. Surv., 12th Ann. Rept., pt. 2, pp. 363–561, 1891.

Describes pump wells (p. 369) and wells for irrigation (pp. 415, 496). Underground seepage waters are sometimes valuable for irrigation where labor is cheap, but it is doubtful if they will ever be extensively used in America (p. 415). Methods of pumping, including several depending on animal power, are considered (pp. 423–425). Loss from streams by percolation and absorption is described (pp. 431–434).

622 —— American Irrigation Engineering.

U. S. Geol. Surv., 13th Ann. Rept., pt. 3, pp. 101–350, 1892.

Considers springs, ground water, artesian water, etc., as sources of supply (pp. 113–114), and discusses seepage (p. 114). Detailed descriptions of subsurface supplies and the methods of collecting by submerged dams, collecting canals, tunnels, etc., are given (pp. 327–330). The "duty" of well water in Utah (p. 157), the volume and movement of ground water (p. 328), and pumping and lifting methods (pp. 162, 332–328) are also considered.

623 **Wilson** (Herbert M.). Pumping waters for irrigation.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 1, pp. 56, 1896.

Contains a discussion of the kinds of pumps (p. 17), including animal motive powers (pp. 20–25), windmills (pp. 25–35), water wheels and hydraulic rams (pp. 35–45), hot air and gasoline pumps (pp. 45–46), steam pumps (pp. 46–50), centrifugal and rotary pumps (pp. 50–51), and mechanical and siphon elevators (pp. 51–54). The relative efficiency and cost are given (pp. 15, 16, 19, etc.). The descriptions of the methods of ancient or semicivilized peoples are of special interest.

624 —— Irrigation in India.

U. S. Geol. Surv., Water-Supply and Irrigation Paper no. 87, pp. 238, 1903.

This is a revised edition of paper on same subject appearing in the Twelfth Annual Report. Very few new facts relating to underground waters are presented.

625 **Winslow** (Arthur). The disseminated lead ores of southeastern Missouri.

U. S. Geol. Surv., Bull. no. 132, pp. 31, 1896.

Contains a number of boring records and notes on fissure and crevice systems in their relation to the deposition of the ores by circulating waters.

626 **Woodworth** (Jay Backus). The glacial brick clays of Rhode Island and southeastern Massachusetts: Geology and geography of the clays.

U. S. Geol. Surv., 17th Ann. Rept., pt. 1, pp. 975–988, 1896.

Describes the mud springs or mud volcanoes in the clays at Barrington, Rhode Island, and at Titicut, Massachusetts. They are thought to be due to water passing downward beneath the clay through the foresets of adjacent sand plains and forcing its way upward through the clay (p. 988).

627 —— Geology of the northern and eastern portions of the Narragansett Basin.

U. S. Geol. Surv., Mon., vol. 33, pp. 91–214, 1899.

Gives records of deep borings in Rhode Island (pp. 161 and 171) and in Massachusetts (pp. 170, 198).

628 **Wright** (George Frederick). The glacial boundary in western Pennsylvania, Ohio, Kentucky, Indiana, and Illinois.

U. S. Geol. Surv., Bull. no. 58, pp. 39–110, 1890.

Describes an artesian well at Oberlin, Ohio (p. 47), and mentions a number of surface wells.

CLASSIFIED KEY TO PRINCIPAL SUBJECT ENTRIES IN INDEX.

	Page.
Absorption of water by—	
Fissures	101
Granite	101
Gravel	101
Lava	101
Limestone	101
Pumice	101
Rocks in general	101
Sand hills	101
Sinks	101
Absorption of water of—	
Canals	101
Rainfall	101
Streams, including lost rivers and intermittent streams	101
General	101
Analyses	101
Brines	101
Mine waters	102
Public supplies	102
Spring deposits	102
Spring waters	102
Well incrustation	102
Well waters	102
Work of United States Geological Survey on	102
General paper	102
Artesian requisites and conditions, general	103
Bibliographies containing reference to underground waters	103
Breathing or blowing wells	103
Brines and salt waters	103
Descriptions	103
General	103
Capacity of materials	104
Circulation and movements of underground waters	104
Causes	104
Descriptions	104
Classification	104
Springs	104
Underground waters	104
Composition or quality	105
Springs	105
Wells and underground waters	105
General papers	106
Contamination	106
Springs	106
Wells	106
Cost of pumping	106

Page.
Cost of wells 106
Deposits by underground waters 106
Cave waters 106
Ground waters 106
Mine waters 106
Springs 106
Wells 106
General papers 106
Discharge 106
Springs 106
Decrease 107
Measurements 107
Statistics 107
Wells 107
Decrease 107
Failure 107
Fluctuations 107
Measurements 107
Regulation 107
Statistics 107
General 107
Experiments 107
Flow of water in porous media 107
Motion of underground waters 107
Faults, relation of springs to 107
Faults, relation of wells to 108
Fissures 108
Absorption of water by 108
Movement of water in 108
Relation of springs to 108
Waters of 108
Fluctuations of groundwater level 108
Barometric pressure, effect of 108
Causes of 108
Descriptions or discussions 108
Folds, relation of springs to 108
Geysers 108
Geyser action 108
Hydrologic work on underground waters 109
Individuals 109
United States Geological Survey 109
Instruments for measuring underflow 111
Joints, relation of springs to 111
Joints, waters in 111
Laws relating to underground water 111
Mine waters 113
Deposits 113
Descriptions 113
Use for water supply 113
Mineral waters 113
Bibliography 113
Economic products 113
Production in the United States 113

Ore deposits, part of underground waters in formation of— Page.
General relations ... 116
Localities ... 116
Porosity ... 117
Rocks ... 117
Sands ... 117
Soil ... 117
General ... 117
Public supplies from underground sources ... 117
Pumping and other methods of lifting water ... 117
Cost ... 117
Descriptions ... 117
Pumping machinery ... 117
Efficiency ... 117
Types ... 117
Turbines ... 117
Windmills ... 117
Records ... 117
Geologic ... 117
Borings and wells ... 117
Statistical ... 118
Springs ... 118
Wells ... 118
Seepage ... 118
Solution by underground waters, work of ... 118
Basins ... 118
Caves and caverns ... 118
Channels ... 118
Coves ... 118
Fissures ... 118
Sinks ... 118
General ... 118
Springs ... 119
Classification ... 119
Descriptions ... 119
Springs in general ... 119
Localities ... 119
General papers ... 120
Types of waters ... 120
Alum ... 120
Brine ... 120
Chalybeate ... 120
Oil and gas ... 120
Sulphur ... 120
Solfataras ... 120
Thermal springs ... 120
Structures ... 121
Collecting ditches ... 121
Collecting galleries ... 121
Collecting and drainage tunnels ... 121
Infiltration works ... 121
Subsurface dams ... 121
Underflow canals ... 121

Page.
Temperature 121
Springs 121
Wells 121
General papers 121
Underground water, movements of 122
Underground waters, occurrence of 122
Formations 122
Arikaree 122
Benton 122
Berea grit 122
Blackwater hole bed 122
Brule clays 122
Calaveras 122
Chadron 123
Chattanooga shale 123
Chesapeake 123
Chester Valley limestone 123
Chickies quartzite 123
Clinton 123
Columbia 123
Comanche Peak 123
Corniferous limestone 123
Corsicana 123
Cretaceous marl 123
Dakota sandstone 123
Denison 123
Devonian limestone 123
Edwards limestone 123
Galena limestone 123
Gering 123
Glen Rose 123
Hudson River shales 123
John Day 123
Knox dolomite 123
Lafayette 123
Lakota sandstone 123
Laramie 123
Leona 123
Lower Magnesian limestone 123
Magophy 123
Manasquan 123
Marshall 123
Matawan 123
Medina 123
Middle marl 123
Minnekahta 123
Minnelusa 123
Monmouth 123
Myrick 123
Navesink 123
Newark 123
Newman 123
Niagara limestone 123

Underground waters, occurrence of—Continued. Page.
Formations—Continued.
Niobrara ... 123
Ogallala ... 123
Ohio shale ... 123
Onandaigua ... 123
Pahasapa ... 123
Paluxy ... 123
Pamunkey ... 123
Payette ... 124
Pierre shales ... 124
Poison Canyon ... 124
Potomac ... 124
Potsdam sandstone ... 124
Rancocas ... 124
Raritan ... 124
Red Bank ... 124
Rutledge limestone ... 124
St. Peter sandstone ... 124
Severn ... 124
Shark River ... 124
Sioux quartzite ... 124
Travis Peak ... 124
Trenton limestone ... 124
Trinity ... 124
Upper Heldeberg limestone ... 124
Waverly ... 124
Wissahickon gneiss ... 124
Woodbine ... 124
Materials ... 124
Alluvium ... 124
Andesite ... 124
Basalt ... 124
Crystalline rocks ... 124
Delta deposits ... 124
Dolomites ... 124
Drift ... 124
Dune sands ... 124
Granite ... 124
Gravel ... 124
Igneous rocks ... 124
Lava ... 124
Limestone ... 124
Sand ... 124
Sandstone ... 124
Serpentine ... 124
Shale ... 124
Stream deposits ... 124
Structures ... 124
Earthquake fissures ... 124
Faults ... 124
Fissile rocks ... 124
Fissures ... 124
Joints ... 124

Underground waters, occurrence of—Continued. Page.
Structures—Continued.
Underground channels 124
Vesicules 124
Systems 125
Silurian 125
Devonian 125
Carboniferous 125
Cretaceous 125
Tertiary 125
Eocene 125
Miocene 125
Neocene 125
Oligocene 125
Quaternary 125
Pleistocene 125
Underground waters, work of 125
Alteration of rocks 125
Cementation 125
Dolomitization 125
Enlargement of quartz grains 125
Ferration 125
Landslides 125
Metamorphism 125
Oxidation 125
Petrifaction 125
Silicification 125
Weathering 125
United States 125
Principal survey publications on underground waters 125
Uses of underground waters 125
Springs 125
Bathing 125
Heating 125
Irrigation 125
Medicinal 125
Power 125
Resorts 125
Public supplies 125
General 125
Wells 126
Bathing 126
Heating 126
Irrigation 126
Lake supplies 126
Power 126
Water supplies 126
General 126
Wells and borings 127
Construction 127
Arrangement 127
Drilling and casing 127
Testing 127
Contamination of 127
Interference of 127

INDEX.

[The numbers refer to entries in the bibliographic review.]

Absorption of water by—
- Fissures, 284.
- Granite, 284.
- Gravel, Massachusetts, 493.
- Lava:
  - Arizona, 426.
  - Idaho, 473.
  - Oregon, 289.
- Limestone:
  - Montana, 336.
  - New York, 455.
- Pumice, Oregon, 289.
- Rocks in general:
  - California, 286.
  - Colorado, 149.
- Sand hills, Nebraska, 529.
- Sinks:
  - General, 500.
  - Michigan, 364.

Absorption of water of—
- Canals (see also Seepage), New York, 455.
- Rainfall, 149, 454.
- Streams, including lost rivers and intermittent streams:
  - Alabama, 362.
  - Arid regions, 342.
  - Arizona, 127, 128, 463a.
  - California, 287.
  - Colorado, 175, 345.
  - India, 621, 624.
  - Kansas, 213.
  - Michigan, 371.
  - Montana, 10, 586, 591, 593, 594.
  - Nebraska, 273.
  - North Carolina, 371.
  - Oregon, 288, 289.
  - Rio Grande Basin, 437.
  - Tennessee, 219.
  - Texas, 243.
  - General, 435.
- General, Nebraska, 100.

Alabama.
- Absorption of water from rivers, 362.
- Mineral waters, production of. See Mineral waters.
- Ore deposits, part of underground waters in formation of, 225.
- Principal survey publications (well records), 502.

Alabama—Continued.
- Springs:
  - Analyses, 392.
  - Descriptions, 392.
  - Measurements, 204.
  - Quality, 392.
  - Use, 392, 406.
  - Yield, 392, 406.
- Underground waters, 437, 502.
- Wells and borings:
  - Analyses, 59, 502.
  - Descriptions, 502.
  - Quality, 502.
  - Records, 501, 502.
  - Temperature, 95, 502.
  - Uses, 502.
  - Yield, 502.
- Work of U. S. Geological Survey, 167, 580.

Alaska.
- Ore deposits, part of underground waters in formation of, 325.
- Springs:
  - Deposits, 70.
  - Descriptions:
    - Mineral, 392, 498.
    - Oil, gas, and sulphur, 325.
    - Sulphur, 70.
  - Quality, 392.
  - Temperature, 392.
  - Use, 392.
  - Yield, 392.

Algiers.
- Wells, use for irrigation, 337.

Alluvium, occurrence of waters in, 101, 215, 549.

Alteration of rocks by springs, 201, 311, 587, 595.

Analyses.
- Brines:
  - England, 131.
  - France, 131.
  - Michigan, 131.
  - New York, 131.
  - Ohio, 449.
  - Ontario, 131.
  - Pennsylvania, 131.
  - South Dakota, 102.
  - United States, 120.
  - Virginia, 131.
  - West Virginia, 131.
  - Wyoming, 102.

Analyses—Continued.
Mine waters:
Colorado, 144.
Nevada, 20.
Pennsylvania, 294.
Public supplies:
Vermont, 420.
Spring deposits:
Siliceous sinter, Montana, 589.
General, 260.
Spring waters:
Alabama, 392.
Alaska, 392.
Arkansas, 59, 60, 392, 446.
California, 53, 60, 308, 392, 477.
Colorado, 60, 392, 461, 519.
Connecticut, 183, 392.
Dakotas, 392.
Delaware, 392.
Florida, 169, 392.
Georgia, 327, 392.
Idaho, 392.
Illinois, 60, 392.
Indiana, 392.
Indian Territory, 392.
Iowa, 392.
Kansas, 392.
Kentucky, 392.
Louisiana, 392.
Maine, 18, 392.
Maryland, 392.
Massachusetts, 73, 139, 392.
Michigan, 71, 280, 392.
Minnesota, 207, 392.
Mississippi, 392.
Missouri, 62, 63, 392, 497.
Montana, 53, 54, 55, 392, 594.
Nebraska, 392.
Nevada, 53, 392, 476.
New Hampshire, 29, 392.
New Jersey, 392.
New Mexico, 55, 59, 64, 392.
New York, 64, 392.
North Carolina, 60, 392.
Oregon, 53, 313, 392, 427.
Pennsylvania, 294, 392.
Porto Rico, 241.
Rhode Island, 74, 392.
South Carolina, 392.
South Dakota, 89, 392.
Tennessee, 61, 364, 392.
Texas, 392.
United States, 392.
Utah, 53, 56, 392.
Vermont, 392, 420.
Virginia, 53, 54, 56, 392.
Washington, 392, 426.
West Virginia, 392.
Wisconsin, 392.
Wyoming, 54, 58, 65, 178, 392.
Yellowstone National Park, 54, 58, 178, 191, 393.
Well incrustations, Pennsylvania, 55.
Well waters:
Alabama, 59, 502.
Arizona, 283.
Arkansas, 446.
Analyses—Continued.
Well waters—Continued.
Colorado, 138, 174.
Connecticut, 183.
Florida, 61, 169.
Georgia, 59, 327.
Illinois, 9, 300.
Indiana, 9, 301.
Iowa, 56.
Kentucky, 61, 177.
Louisiana, 210.
Maine, 18.
Massachusetts, 61, 78, 139, 140.
Michigan, 71, 280.
Missouri, 60, 514.
Nebraska, 103.
New Hampshire, 29.
New York, 610.
North Carolina, 97.
Pennsylvania, 294.
Rhode Island, 74.
South Dakota, 89, 102, 103.
Texas, 239.
Vermont, 420.
Virginia, 97.
Wyoming, 58, 102.
Work of the U. S. Geological Survey on, 57, 167, 168.
General paper:
Methods of analysis, 57.
Andesite, occurrence of waters in, 458.
Anticlines, relation of springs to, in Wyoming, 186.
Arid regions, absorption of streams, 342.
Arikaree formation, occurrence of waters in, 90, 101.
Arizona.
Absorption of streams, 127, 128, 463a.
Brines, 616.
Mine waters, 463.
Mineral waters, production of. See Mineral waters.
Ore deposits, part of underground waters in formation of, 462, 463, 463a, 465.
Porosity of gravel, 283.
Principal Survey publications:
Irrigation near Phoenix, 106.
Underground waters of Gila Valley, 283.
Underground waters of Salt River Valley, 251.
Water resources of Salinas Valley, 208.
Seepage, 106, 362.
Seepage ditches, 283.
Springs:
Analyses, 392.
Descriptions, 127, 128, 290, 392, 428.
Quality, 392.
Temperature, 392.
Use, 392, 406.
Yield, 392, 406.
Underground waters:
Circulation, 283.
Composition, 25.
Descriptions, 106, 282, 283, 465.
Evaporation, 84.
Experiments on motion, 283.
Movements, 283.

Arizona—Continued.
Wells:
Capacity, 283.
Composition, 283.
Descriptions, 283, 346, 362, 463a, 465.
Irrigation, 107, 282.
Pumping, 106, 282, 283.
Records, 283, 463.
Statistics, 106.
Tests, 283.
Work of U. S. Geological Survey, 104, 471, 580.
Arkansas.
Mineral waters, production of. See Mineral waters.
Ore deposits, part of underground waters in formation of, 5, 6, 11, 223, 564.
Principal Survey publication (well and spring records), 446.
Springs:
Analyses, 59, 60, 392, 446.
Descriptions, 1, 392, 446.
Quality, 392, 446.
Temperature, 392, 446.
Uses, 392, 406, 446.
Yield, 392, 406, 446.
Underground waters:
Circulation, 5, 6, 11.
Occurrence, 446.
Wells:
Analyses, 446.
Descriptions, 446.
Quality, 446.
Records, 446.
Temperature, 95.
Yield, 446.
Work of U. S. Geological Survey, 167, 471, 580.
Artesian requisites and conditions, general, 45, 138, 242, 245, 328, 333, 334, 437, 480, 481, 484, 488, 500, 506, 561.
Artesian waters. See Underground waters.
Artesian wells. See Wells.
Atlantic Coastal Plain, general.
Underground waters, 86.
Water horizons, 86.
Wells, 86.
Work of the U. S. Geological Survey, 572.
Azores, springs, 584.
Basalt, occurrence of water in, 569.
Bathing, use of wells and springs for, 148, 317, 426, 487, 594.
Bedding planes, waters in, 565.
Benton formation, occurrence of water in, 543, 544, 545, 588.
Berea grit, occurrence of water in, 280.
Bibliographies containing references to underground waters—
Geology, 78, 79, 80, 81, 85, 599, 600, 601, 602, 603, 604, 605, 606, 607, 609, 611.
Groundwater movements, 499.
Hayden, King, Powell, and Wheeler surveys, 491.
Irrigation literature, 32.
Survey publications, lists of, 166, 227, 283, 577, 578a, 581, 582, 583.
Underground waters, general, 484, 488, 577.
Boring, methods of. See Wells and borings, construction.
Borings. See Records; also Wells.
Breathing or blowing wells.
Great Plains, 214.
Nebraska, 14.
Brines and salt waters.
Descriptions:
Arizona, 616.
California, 112, 134, 616, 619.
Colorado, 616, 619.
Dakotas, 616.
Idaho, 112, 616.
Illinois, 619.
Indiana, 379, 422, 619.
Kansas, 213, 450, 619.
Kentucky, 619.
Louisiana, 226, 235.
Michigan, 112, 280, 448, 451, 532, 616, 619.
Minnesota, 560.
Montana, 616, 619.
Nebraska, 4, 14, 619.
Nevada, 112, 616.
New York, 112, 448, 449, 450, 451, 616, 619.
North Dakota, 560.
Ohio, 108, 379, 449, 616, 619.
Pennsylvania, 525.
South Dakota, 102, 619.
Tennessee, 619.
Texas, 226, 229.
Virginia, 131, 619.
Western Gulf coast, 2.
West Virginia, 108, 449, 616.
Wyoming, 4, 102.
General:
Brines as a source of bromine, 111, 118.
Brines as a source of iodine, 109.
Brines as a source of potassium salts, 120.
Brines as a source of salt, 381, 382, 383, 384, 385, 386, 387, 388, 389, 616.
Brines, origin of, 422.
Brines, chemistry and production of, 51.
Relations of salt water to the occurrence of oil and gas, 150, 226, 525.
Bromine from mineral waters, 111, 118.
Brulé shale, occurrence of water in, 4, 90, 101.
Calaveras formation, occurrence of water in, 554.
California.
Absorption of streams, 281.
Brines, 112, 134, 616, 619.
Caves, 551, 554.
Geysers, 121.
Mine waters, 312.
Mineral waters, production of. See Mineral waters.
Ore deposits, part of underground waters in formtion of, 22, 308, 595.
Principal Survey publications:
Development and application of water near San Bernardino, Colton, and Riverside, 321, 322.
California hydrography, 328.
Irrigation near Bakersfield, 187.
Irrigation near Fresno, 188.
Storage of water on Kings River, 320.
Water storage, Cache Creek, 49.
Water supply of San Bernardino Valley, 319.
Pumping, general, 365.

California—Continued.
Seepage, 188, 320, 322.
Solfataras, 121.
Springs:
Analyses, 53, 60, 308, 392, 477.
Brine, 134.
Composition, 22, 308, 392, 477.
Deposits, 67, 121, 308, 477.
Descriptions, 22, 105, 121, 134, 148, 170, 251, 286, 307, 312, 319, 321, 392, 458, 477, 509.
Failure, 533.
Occurrence on—
Earthquake fissure, 477, 553.
Faults, 477, 553.
Temperature, 392.
Thermal, 22, 121, 553.
Uses:
Bathing, 148.
Irrigation, 477.
Resorts, 406.
General, 392.
Yield, 392, 406.
Tunnels, collecting, 287, 323, 366.
Underground waters:
Absorption by rocks, 286.
Circulation, 321.
Composition, 320.
Descriptions, 105, 188, 208, 287, 321, 347, 362.
Movement of underflow, rate of, 321.
Occurrence:
Delta deposits and gravel fans, 320, 323.
Stream deposits, 208.
General, 364.
Raising of, 322.
Rise of, by irrigation, 187.
Temperature due to igneous action, 477.
Work of solution, 551, 554.
Water horizons, 554.
Wells:
Brines, 112.
Composition, 307, 320, 322.
Construction, 258, 259, 378.
Cost, 49.
Descriptions, 208, 285, 307, 553.
Discharge, 49, 251, 255, 319, 322, 378.
Failure, 533.
Irrigation, 49, 187, 208, 321.
Penetration of sea water into, 509.
Pumping, 49, 187, 208, 251, 320, 322, 365.
Records, 208, 307.
Statistics, 320, 322, 323.
Temperature, 95.
Work of U. S. Geological Survey, 104, 471, 572, 573, 580.
Canada (Manitoba), wells and springs, 560.
Canal waters, absorption of, in New York, 455.
Capacity of materials. See also Porosity.
Rocks, 277, 499, 500, 565.
Sands, 362, 453, 456, 499, 500.
Soils, 277, 362, 499, 500.
Capacity of springs and wells. See Discharge.
Carboniferous waters. See Underground waters, occurrence of, systems.
Cascade Mountains, springs, 129.
Catchment conditions. See Artesian requisites.
Caves and caverns. See Solution, caves and caverns.
Cave waters, deposits of, 122, 263.
Cementation by underground waters, 522, 565.
Chadron formation, occurrence of water in, 90.
Channels. See Solution, channels.
Chattanooga shale, occurrence of water in, 272.
Chemistry of underground waters. See Composition and quality.
Chesapeake formation, occurrence of water in, 86, 87.
Chester Valley limestone, occurrence of water in, 16.
Chickies quartzite, occurrence of water in, 16.
Cinnabar, deposits of, from springs, 23.
Circulation and movements of underground waters.
Causes:
Capillarity, 277.
Deformation, 277.
Gravity, 277.
Heat, 277.
Rock consolidation, 277.
General. See Artesian requisites and conditions.
Descriptions:
Arizona, 283.
Arkansas, 5, 6, 11.
California, 321.
Florida, 77.
Minnesota, 296.
Missouri, 11.
Tennessee, 272.
Washington, 505.
Wyoming, 517.
Fissures, movement of water in, 277.
Limits of depth, 500, 561, 565.
Porous media, circulation in, 277.
Principles of (see also Artesian requisites), 11, 45.
General, 45, 343, 456, 499, 565, 622.
Classification.
Springs, 392, 406.
Underground waters, 302.
Clinton formation, occurrence of water in, 280.
Collecting ditches, galleries, and tunnels. See Structures.
Colorado.
Absorption of rainfall by rocks, 149.
Absorption of streams, 175, 345.
Brines, 616, 619.
Caves in limestone, 141.
Mine waters:
Analyses, 144.
Composition, 144.
Deposits, 144.
Descriptions, 144, 318, 447, 461.
Mineral waters, production of. See Mineral waters.
Ore deposits, part of underground waters in formation of, 141, 142, 144, 414, 447, 460, 461, 519.
Principal Survey publications:
Elmoro folio, 244.
Geology of Denver Basin, 138.
Irrigation near Greeley, 280.
Pueblo folio, 175.
Spanish Peaks folio, 246.
Underground waters of Arkansas Valley, 174.

Colorado—Continued.
Principal Survey publications—Continued.
Walsenburg folio, 245.
Water resources, 149.
Seepage, 142, 149, 257, 345, 362.
Settling of ground due to ground water, 326.
Springs:
Analyses, 60, 392, 519.
Composition, 75, 392, 516.
Deposits, 137, 142, 447, 461, 516.
Descriptions, 137, 141, 142, 244, 264, 357, 362, 392, 461, 516.
Gases of, 516.
Temperature, 392.
Thermal, 137, 142, 357.
Uses, 392.
Yield, 392, 406.
Tunnels, drainage, 102.
Underground waters:
Analyses, 174, 461.
Artesian basins, 354.
Association with oil, 150.
Descriptions, 102, 105, 138, 174, 244, 256, 257, 354, 437.
Landslides caused by ground water, 75.
Legal decisions relating to, 30.
Occurrence in—
Dune sand, 174.
Gravel, 174.
Prospects, 174.
Work of solution, 141, 519.
Wells:
Analyses, 138.
Construction, methods of, 245.
Cost, 245, 345.
Descriptions, 30, 150, 346, 357.
Statistics, 345.
Temperature, 95.
Thermal, 150.
Water horizons, 174, 175, 244, 245, 246.
Work of U. S. Geological Survey, 104, 173, 328, 439, 471, 572, 573, 574, 578.
Columbia formation, occurrence of water in, 78, 86, 87, 94, 97.
Comanche Peak formation, occurrence of water in, 240.
Composition or quality. See also Analyses and Springs.
Gas associated with ground waters, 436, 516, 565.
Mine waters, Colorado, 144.
Springs:
Alabama, 392.
Alaska, 392.
Arizona, 392.
Arkansas, 392–446.
California, 22, 308, 392, 477.
Colorado, 75, 392, 516.
Connecticut, 183, 392.
Dakotas, 392.
Delaware, 392.
Florida, 169, 392.
Georgia, 327, 392.
Idaho, 392.
Illinois, 392.
Indiana, 392.
Indian Territory, 392.
Composition or quality—Continued.
Springs—Continued.
Iowa, 392.
Kansas, 392.
Kentucky, 392.
Louisiana, 392.
Maine, 18, 392.
Maryland, 392.
Massachusetts, 73, 392.
Michigan, 71, 280, 392.
Minnesota, 207, 392.
Mississippi, 392.
Missouri, 63, 392, 497.
Montana, 145, 392, 591.
Nebraska, 392.
Nevada, 392, 477.
New Hampshire, 29, 392.
New Jersey, 392.
New Mexico, 392.
New York, 392, 610.
North Carolina, 392.
Ohio, 392.
Oregon, 392.
Pennsylvania, 392.
Porto Rico, 241, 392.
Rhode Island, 74, 392.
South Carolina, 392.
South Dakota, 392, 589.
Tennessee, 392.
Texas, 392.
United States, 95, 96, 392.
Utah, 392.
Vermont, 392, 420.
Virginia, 392.
Washington, 392.
West Virginia, 392.
Wisconsin, 392.
Wyoming, 392.
Yellowstone National Park, 178, 192, 194, 199, 392, 434.
General, 406.
Wells and underground waters:
Alabama, 502.
Arizona, 283.
Arkansas, 446.
California, 277, 307, 320.
Connecticut, 183.
Dakotas, 84.
Florida, 169.
Kansas, 213.
Kentucky, 177.
Louisiana, 164, 210.
Massachusetts, 73.
Michigan, 71, 280.
Minnesota, 207, 546.
Mississippi, 266.
Missouri, 497.
Molokai, 314.
New Hampshire, 29.
New Mexico, 234, 429.
New York, 610.
Ohio, 419.
Rhode Island, 74.
Tennessee, 176.
Texas, 236, 242.
Vermont, 420.

Composition or quality—Continued.
General papers:
Composition near trap dikes, 478.
Composition in relation to petrology, 487.
General composition of ground waters, 292, 293, 494.
Connecticut.
Principal Survey publications:
Additional well records, 48, 181.
Well and spring records, 183.
Springs:
Analyses, 183, 392.
Descriptions, 183, 392.
Occurrence on faults, 247, 500.
Quality, 183, 392.
Temperature, 183, 392.
Uses, 183, 392, 406.
Yield, 183, 392, 406.
Underground water conditions, 183.
Wells:
Analyses, 183.
Cost, 48.
Descriptions, 48, 181, 183.
Quality, 183.
Temperature, 183.
Uses, 183.
Yield, 48, 181, 183.
Work of U. S. Geological Survey 167, 580.
Contamination.
Springs, 500.
Wells, 494, 500, 509.
Corniferous limestone, occurrence of water in, 380.
Corsicana formation, occurrence of water in, 242.
Cost of pumping, etc., 320, 356.
Cost of wells.
California, 49.
Colorado, 345.
Connecticut, 48.
Kansas, 345.
Massachusetts, 47.
Nebraska, 345.
Coves. See Solution, Coves.
Craterlets formed by underground waters during Charleston earthquake, 130.
Cretaceous waters. See Underground waters, occurrence of, systems.
Crystalline rocks, occurrence of water in, 318.
Dakotas. See also North and South Dakota.
Artesian conditions, 84.
Brines, 616.
Principal Survey publications:
Artesian waters of a portion of the Dakotas, 84.
Springs:
Analyses, 392.
Descriptions, 392.
Quality, 392.
Temperature, 392.
Uses, 392.
Yield, 392.
Underground waters:
Composition, 84.
Irrigation, 84.
Power, use for, 84.
Pressure and head, 84.
Volume, 84.
Well construction, 84.
Work of U. S. Geological Survey, 471.
Dakota sandstone, occurrence of water in, 84, 90, 91, 93, 98, 100, 101, 173, 174, 175, 212, 213, 244, 245, 246, 354, 500, 539, 542, 543, 544, 560, 613.
Decay of rock due to percolating waters, 478.
Delaware.
Mineral waters, production of. See Mineral waters.
Springs:
Quality, 392.
Use, 392.
Water horizons, 86.
Wells:
Descriptions, 86.
Prospects, 86.
Records, 77.
Temperature, 86.
Delta deposits, occurrence of water in, 320.
Denison formation, occurrence of water in, 242.
Deposits by underground waters—
Cave waters:
Texas, 236.
Utah, 146.
General, 122.
Ground waters:
Crusts by evaporation of, 494.
Underground deposition of gypsum, Kansas, 184.
Mine waters, Colorado, 144.
Springs:
Cinnibar, 23.
Salt, 555.
Sulphur:
Alaska, 70.
California, 121.
Wyoming, 201.
Tufa, travertine, siliceous sinter, etc.:
California, 308, 477.
Colorado, 137, 447, 461, 516.
Georgia, 48.
Idaho, 311.
Indiana, 159, 162.
Montana, 145, 261, 588, 589, 595, 597.
Nebraska, 103.
Nevada, 7, 476, 521.
North Dakota, 538.
Oregon, 313, 427.
South Dakota, 103, 538.
Texas, 260.
Wyoming and Yellowstone National Park, 137, 192, 193, 194, 199, 584, 587.
General, 590.
Well incrustations, Pennsylvania, 55.
General papers:
Antiquity of geyser and hot springs of Yellowstone National Park, 199.
Exhibit of hot spring deposits at the Chicago World's Fair, 198.
Mud cones, Rhode Island and Massachusetts, 626.
Theoretical structure of spring deposits as compared with deposits of Lake Lahonton, 474.
Devonian limestone, occurrence of water in, 556.
Devonian waters. See Underground waters, occurrence of, systems.
Discharge.
Springs:
Decrease of, Georgia, 105.

Discharge—Continued.
Springs—Continued.
Measurements:
Alabama, 204.
Florida, 208.
Georgia, 111, 202, 253, 327.
Nebraska, 254.
Texas, 252, 254, 257, 260, 347, 357, 372, 392, 536, 537, 568, 572.
Statistics:
Alabama, 392, 406.
Alaska, 392.
Arizona, 392.
Arkansas, 392, 446.
California, 406.
Colorado, 392.
Connecticut, 183, 392.
Dakotas, 392.
Delaware, 392.
Florida, 169, 203, 392.
Georgia, 202, 327, 392, 406.
Idaho, 392, 406.
Illinois, 392, 406.
Indiana, 392, 406.
Indian Territory, 392, 406.
Iowa, 392, 406.
Kansas, 392, 406.
Kentucky, 392, 406.
Louisiana, 392, 406.
Maine, 18, 392, 406.
Maryland, 392, 406.
Massachusetts, 73, 392, 406.
Michigan, 71, 392, 406.
Minnesota, 207, 392, 406.
Mississippi, 392, 406.
Missouri, 392, 406, 497.
Montana, 392, 406.
Nebraska, 406.
Nevada, 392.
New Hampshire, 29, 392, 406.
New Jersey, 392, 406.
New Mexico, 392, 406.
New York, 392, 406, 610.
North Carolina, 392, 406.
Ohio, 406.
Oregon, 392.
Pennsylvania, 406.
Rhode Island, 73, 392, 406.
South Carolina, 406.
South Dakota, 406.
Tennessee, 392, 406.
Texas, 372, 392, 406.
Utah, 392, 406.
Vermont, 392, 406, 420.
Virginia, 392, 406.
Washington, 392, 406.
West Virginia, 392, 406.
Wisconsin, 392, 406.
Wyoming, 392.
Yellowstone National Park, 392.
Wells:
Decrease of:
California, 533.
Georgia, 105.
Illinois, 19.
Kansas, 346.
South Dakota, 545.
General, 45, 500.
Discharge—Continued.
Wells—Continued.
Failure, 45.
Fluctuations, 210.
Measurements, 277, 500.
Regulation of, 484.
Statistics:
Alabama, 502.
Arizona, 283.
Arkansas, 446.
California, 255, 258.
Connecticut, 48, 181, 183.
Dakotas, 84.
District of Columbia, 94.
Delaware, 86.
Florida, 169.
Georgia, 327.
Kentucky, 177.
Maine, 18.
Maryland, 86.
Massachusetts, 47, 73.
Michigan, 71.
Minnesota, 207, 546.
Mississippi, 266.
Missouri, 497.
New Hampshire, 29.
New Jersey, 86.
New York, 610.
North Carolina, 86.
Rhode Island, 73.
South Carolina, 86.
United States, 95, 96.
Vermont, 420.
Virginia, 86.
Washington, 369.
General, 45, 277, 500.
District of Columbia.
Mineral waters, production of. See Mineral water.
Principal Survey publications:
Artesian-well prospects in the Atlantic Coastal Plain, 86.
Washington folio, 94.
Underground waters, 86, 94, 335.
Water horizons, 86, 94.
Wells:
Descriptions, 86, 94.
Records, 86-94.
Temperature, 86.
Work of U. S. Geological Survey, 574, 576.
Dolomite, occurrence of water in, 5.
Dolomitization by underground waters, 519.
Drift, occurrence of water in, 9, 162, 249, 300, 301, 302, 303, 304, 305, 380, 547.
Drilling, methods of. See Well construction.
Dune sands, occurrence of water in, 174.
Edwards limestone, occurrence of water in, 239, 240, 242, 243, 569.
Enlargement of quartz grains by underground waters, 263.
Erie-Ohio Basin.
Underground waters and wells, 306.
Experiments.
Flow of water in porous media, 277, 499, 500.
Motion of underground waters in Arizona, 283.
Faults, relation of springs to.
California, 477, 553.
Connecticut, 247, 500.

Faults, relation of springs to—Continued.
Idaho, 308.
Nevada, 476.
Oregon, 475.
Texas, 239, 240, 569.
Utah, 170.
Faults, relation of wells to, Massachusetts, 140.
Farration by underground waters, 519.
Filtration, natural, during absorption of water, 452.
Fissility, relation of waters to, 565.
Fissures.
Absorption of water by, 284.
Movement of water in, 277.
Relation of spring to:
Nevada, 476.
Texas, 239, 240, 569.
Waters of, 239, 277, 284, 480.
Florida.
Mineral waters, production of. See Mineral waters.
Principal Survey publications:
Measurement of springs in Florida, 203.
Well and spring records, 169.
Sinks, 77.
Springs:
Analyses, 159, 392.
Descriptions, 77, 169, 203, 392.
Measurements, 203.
Quality, 169, 392.
Temperature, 169, 392.
Thermal, 434.
Uses, 169, 392.
Yield, 169, 202, 392, 406.
Wells:
Analyses, 61, 169.
Descriptions, 169.
Quality, 169.
Records, 77, 169.
Temperature, 95–169.
Uses, 95, 169.
Yield, 169, 203.
Underground waters:
Circulation, 77.
Conditions, 169.
Temperature, 484, 485.
Work of solution, 77.
Work of U. S. Geological Survey, 167, 439, 580.
Fluctuations of ground-water level.
Barometric pressure, effect of, 565.
Causes of, in Nebraska, 528.
Descriptions or discussions:
Nebraska, 14, 528.
South Dakota, 540.
General, 456, 565.
Folds, relation of springs to, 136.
Galena formation, occurrence of water in, 332, 556.
Gases of underground waters. See Composition.
Georgia.
Mineral waters, production of. See Mineral waters.
Ore deposits, part of underground waters in formation of, 218, 225, 228, 230, 231.
Principal Survey publications:
Measurement of springs, 202.
Water-supply, well, and spring records, 327.
Georgia—Continued.
Springs:
Analyses, 327, 392.
Descriptions, 105, 327, 392.
Deposits, 327.
Measurements, 111, 202, 258, 327.
Quality, 327, 392.
Temperature, 392.
Uses, 327, 392, 406.
Yield, 202, 327, 392, 406.
Underground water conditions, 327.
Water horizons, 86.
Water supplies from underground sources, 327.
Wells:
Analyses, 59, 327.
Descriptions, 86, 327, 500.
Irrigation from, 362.
Pumping from, 362.
Quality, 327.
Records, 86.
Temperature, 95.
Yield, 202, 327.
Work of U. S. Geological Survey, 167, 471, 580.
Gering formation, occurence of water in, 90.
Geysers.
California, 121.
Iceland, 21.
Yellowstone National Park:
Action in, 192, 193, 194, 195.
Antiquity of action, 199.
Changes in action, 434.
Deposits, exhibit of, at Chicago World's Fair, 198.
Work of U. S. Geological Survey, 189, 190, 192, 193, 194, 195, 196.
Geyser action.
Work of U. S. Geological Survey on, 190, 191.
Glen Rose formation, occurrence of water in, 242, 569.
Granite, absorption of water by, 284.
Granite, occurrence of water in, 310.
Gravel, absorption of water by, in Massachusetts, 493.
Gravel, occurrence of water in, 174, 283, 323.
Great Plains.
Principal Survey publications:
Water resources of a portion of the Great Plains, 214.
Springs, 214.
Water horizons, 214.
Wells:
Blowing, 214.
Irrigation from, 72.
Pumping from, 72.
Temperature, 214.
Work of U. S. Geological Survey, 577.
Ground water. See Underground waters.
Head, general discussions of, 45, 500.
Head, influence of heat on, 565.
Health, relation to deep wells, 578.
Heating, use of springs for, 487.
Heating, use of wells for, 487.
High Plains.
Principal Survey publications:
High plains and their utilization, 267, 268.
Sinks, 267.
Springs, 267.

High Plains—Continued.
Underground water:
Catchment conditions, 267.
Descriptions, 267, 268.
Work of solution, 267.
Water horizons, 267.
Wells:
Construction, 267.
Description, 267.
Work of U. S. Geological Survey, 361.
Hot springs. See Springs.
Hudson River shales, occurrence of water in, 556.
Hydrologic work on underground waters, including analyses. (See also State entries.)
Individuals:
Ainsworth, F. H., 575.
Alden, W. C., 580.
Anderson, J. A., 167.
Babcock, E. J., 574, 575.
Barbour, E. H., 104, 573, 574, 578.
Bayley, W. S., 167, 580.
Benton, S. S., 547.
Boutwell, J. M., 167, 580.
Calkins, F. C., 578.
Chatard, T. M., 61.
Clarke, F. W., 55, 59, 60, 63, 64.
Coffin, F. F. B., 349.
Condra, G. E., 104, 580.
Cooper, W. F., 167, 580.
Crosby, W. O., 167, 580.
Darton, N. H., 104, 349, 353, 357, 361, 376, 572, 573, 574, 575, 576, 577, 578, 578a, 580.
Eakins, L. G., 60.
Fisher, C. A., 104, 580.
Fuller, M. L., 167, 580.
Gilbert, G. K., 354, 571, 573.
Glenn, L. C., 167, 580.
Gooch, F. A., 57, 58, 65, 189, 190, 191, 192, 194, 432.
Gould, C. N., 104, 580.
Gregory, H. E., 167, 580.
Hague, Arnold, 578a, 580.
Hall, C. M., 104, 577, 578, 578a, 580.
Hall, C. W., 167, 580.
Hallock, William, 190, 574, 578.
Harris, G. D., 167.
Hayworth, Erasmus, 574.
Hillebrand, W. F., 62.
Hills, R. C., 574, 575.
Hill, R. T., 572, 573, 574, 575, 577.
Hodges, R. S., 167.
Hollick, Arthur, 167.
Homer, Hamlin, 580.
Hood, O. P., 574.
Howard, E. S., 62.
Johnson, L. C., 167, 580.
Johnson, W. D., 361, 363, 574.
Keyes, C. R., 104.
Knapp, G. N., 167, 580.
La Forge, Laurence, 580.
Landes, Henry, 104.
Lane, A. C., 574, 575.
Lawson, A. C., 572, 573.
Lee, W. T., 104, 580.
Leverett, Frank, 349, 359, 572, 573, 574, 575, 578.
Lindgren, Waldemar, 580.
Lord, L. G., 167.
Hydrologic work on underground waters, including analyses—Continued.
Individuals—Continued.
Lovelace, B. F., 167.
McCallie, S. W., 167, 580.
Mendenhall, W. C., 104, 580.
Murphy, E. C., 574.
Newell, F. H., 440, 572.
Norton, W. H., 167, 580.
O'Harra, C. C., 104, 577, 578, 580.
Orton, Edward, 358.
Palmer, A. W., 362.
Peale, A. C., 189, 216, 217, 430, 433, 440.
Perkins, G. H., 167, 580.
Phinney, A. J., 330.
Purdue, A. H., 167, 580.
Redmond, Charles W., 398.
Richardson, G. B., 104, 580.
Riggs, R. B., 55, 56, 59, 60.
Russell, I. C., 104, 441, 578, 580.
Shepard, E. M., 167, 580.
Shultz, A. R., 167, 580.
Siebenthal, C. E., 104.
Sitchell, W. A., 577.
Slichter, C. S., 167, 578, 578a, 580.
Smith, E. A., 167, 580.
Smith, G. O., 167, 580.
Smith, W. S. T., 578.
Todd, J. E., 104, 577, 578, 578a, 580.
Vaughan, T. W., 574.
Veatch, A. C., 167, 580.
Washburn, W. C., 167.
Weed, W. H., 189, 192, 193, 194, 195, 196, 577, 578a.
Weeks, F. B., 167, 580.
Whitfield, J. E., 55, 57, 58, 60, 65, 191, 192, 194, 432.
Wilder, F. A., 104.
Willard, D. E., 104, 580.
United States Geological Survey:
Analyses, collection of, by, 167, 168.
Artesian waters, work on, 335, 344, 353, 355, 357, 572.
Bibliography of springs, 430.
Composition of underground waters, 471.
Division of hydrology, work of, 167, 471, 580.
Drift, work on waters of, 572.
General hydrologic work, 573, 574, 575, 577.
Health, relation of deep wells to, 578.
Mineral waters:
Eleventh Census, 399, 400.
Publications, 395, 396, 397, 400, 401.
General, 395, 396, 397.
Spring data, collection of, 167, 168.
Spring waters, 189.
Underground waters in general, see also under States, 104, 166, 167, 173, 350, 353, 354, 355, 357, 361, 362, 375, 376, 471, 572, 573, 580.
Water-supply data, collection of, 167, 168.
Well data, collection of, 167, 168, 335.
Iceland.
Geysers, 21.
Springs, 584.
Idaho.
Brines, 112, 616.
Mineral waters, production of. See Mineral waters.

Idaho—Continued.
Ore deposits, part of underground waters in formation of, 311.
Principal Survey publications:
Artesian basins of southwestern Idaho and southeastern Oregon; 386, 387, 388.
Geology and water resources Nez Perce County, 383, 384.
Geology and water resources of Snake River Plains, 485.
Nampa folio, 315.
Silver City folio, 316.
Water resources of southeastern Idaho, 482.
Seepage, 105.
Springs:
Analyses, 392.
Deposits, 311.
Descriptions, 284, 310, 311, 317, 392, 473, 482, 483, 484, 487, 488, 523, 524.
Occurrence on faults, 308.
Quality, 392.
Temperature, 316, 392.
Thermal, 311.
Uses:
Irrigation, 310, 374.
Resorts, 406.
General, 392.
Work of, alteration of granite, 311.
Yield, 392, 406.
Thermal springs:
Composition, 310.
Descriptions, 309, 315, 316, 533.
Underground waters:
Descriptions, 364, 482, 483, 484, 485, 487, 488.
Occurrence in:
Fissures in granite, 284.
Lava beds, 473, 482, 483.
Uses, 487.
Work of, solution basins, 483.
Water horizons, 310.
Wells:
Brine, 112.
Descriptions, 315, 316, 346, 483, 488.
Discharge, regulation of, 484.
Records, 315.
Temperature, 95.
Thermal, 310.
Uses for irrigation, 357.
Work of U. S. Geological Survey, 575, 580.
Igneous intrusions, relation of thermal springs to, 145, 586, 595.
Igneous rocks, occurrence of water in, 312.
Illinois.
Artesian conditions, 302.
Brines, 619.
Mine waters, 12.
Mineral waters, production of. See Mineral waters.
Ore deposits, part of underground waters in formation of, 12, 13.
Principal Survey publications:
Chicago folio, 9.
Danville folio, 305.
Patoka folio, 162.
Water resources of Illinois, 300.
Rainfall, 300.
Illinois—Continued.
Springs:
Analyses, 60, 392.
Descriptions, 392.
Quality, 392.
Temperature, 392.
Uses, 392, 406.
Yield, 392, 406.
Underground waters:
Analyses, 300.
Classification, 302.
Decrease in flow, 9.
Descriptions, 300.
Occurrence of—
Drift, 9, 300, 305.
Potsdam sandstone, 9.
St. Peter sandstone, 9.
General, 437.
Use for public supplies, 301.
Water horizons, 556.
Wells:
Descriptions, 302.
Occurrence in—
Carboniferous rocks, 162.
Drift, 87, 162.
Records, 9, 37.
Temperature, 95.
Work of U. S. Geological Survey, 362, 573.
India.
Absorption of streams, 621, 624.
Pumping underground waters, 621, 624.
Seepage, 621, 624.
Wells used for irrigation, 550, 621, 624.
Indiana.
Artesian conditions, 305.
Brines, 379, 422, 619.
Mineral water, production of. See Mineral waters.
Principal Survey publications:
Chicago folio, 9.
Danville folio, 305.
Patoka folio, 162.
Water resources of Indiana and Ohio, 301.
Wells of northern Indiana, 303.
Wells of southern Indiana, 304.
Springs:
Analyses, 392.
Deposits, 159, 162.
Descriptions, 161, 162, 301, 392.
Quality, 392.
Temperature, 392.
Uses, 392, 406.
Yield, 392, 406.
Underground waters:
Analyses, 301.
Descriptions, 301.
Occurrence in:
Drift, 301, 303, 304, 305.
Rock, 301.
Subterranean drainage, 301.
Use for water supplies, 301.
Water horizons, 379, 422.
Wells:
Brines, 379.
Decrease of flow, 9.
Descriptions, 9, 37, 3. 3. 304, 305.

Indiana—Continued.
Wells—Continued.
Occurrence in:
Carboniferous rocks, 162.
Drift, 162.
Records, 37, 158, 159, 303, 304, 305, 422.
Work of U. S. Geological Survey, 330, 574, 576.
Indian Territory.
Springs:
Description, 392.
Quality, 392.
Temperature, 392.
Use, 392.
Yield, 392.
Infiltration works, 491.
Instruments for measuring underflow, 500.
Interference of wells, 277, 499, 500, 540.
Intermittent streams. See Absorption of streams.
Iodine from mineral waters, 109.
Iowa.
Caverns, 332.
Mineral waters, production of. See Mineral waters.
Ore deposits, part of underground waters in formation of, 332.
Springs:
Analyses, 392.
Descriptions, 392.
Quality, 392.
Temperature, 392.
Uses, 392, 406.
Yield, 392, 406.
Underground waters:
Descriptions, 307, 332.
Work of solution, 332.
Water horizon, Galena limestone, 332.
Wells:
Analyses, 56.
Records, 31, 332.
Temperature, 95.
Work of U. S. Geological Survey, 167, 439, 580.
Irrigation, use of wells and springs for. See Uses of underground waters.
John Day formation, occurrence of water in, 480.
Joints, relation of springs to, in Texas, 568.
Joints, waters in, 565.
Kansas.
Absorption of streams, 213.
Brines, 213, 450, 619.
Mineral waters, production of. See Mineral waters.
Ore deposits, part of underground waters in formation of, 510.
Principal Survey publication:
Underground waters of southwestern Kansas, 212.
Sinks, 215.
Springs:
Analyses, 392.
Descriptions, 184, 212, 215, 392, 445, 489.
Quality, 392.
Temperature, 392.
Uses:
Power, 215.
Resorts, 406.
General, 392.
Yield, 392, 406.
Kansas—Continued.
Underground waters:
Deposition of gypsum by, 184.
Descriptions, 212, 330, 331, 437.
Methods of locating, 212.
Work of solution, 215.
Water horizons, 212, 213, 215.
Wells:
Brines, 450.
Composition, 213.
Cost, 345.
Descriptions, 213, 338, 339, 346, 489.
Mineral, 215.
Problems, 579.
Prospects, 212.
Pumping from, 375.
Statistics, 345.
Use for irrigation, 212.
Work of U. S. Geological Survey, 104, 439, 440 574, 578, 580.
Kentucky.
Brines, 619.
Caves, sinks, and channels, 34, 35, 557.
Mineral waters, production of. See Mineral waters.
Ore deposits, part of underground waters in formation of, 511.
Principal Survey publications.
Well records, 177.
Springs:
Analyses, 392.
Descriptions, 34, 35, 392.
Quality, 392.
Temperature, 392.
Uses, 392, 406.
Yield, 392, 406.
Underground water conditions, 177.
Underground water, solution by, 34, 35, 320.
Wells:
Analyses, 61, 177.
Descriptions, 177.
Quality, 177.
Records, 177.
Uses, 177.
Yield, 177.
Work of U. S. Geological Survey, 167, 580.
Knox dolomite, occurrence of water in, 269, 270, 271, 272, 273.
Lafayette formation, occurrence of water in, 78, 86, 87.
Lakes supplied from wells, 89.
Lake Superior district. See also Minnesota, Wisconsin, and Michigan.
Ore deposits, part of underground waters in, formation of, 297, 563.
Lakota formation, occurrence of water in, 93, 102, 108.
Laramie formation, occurrence of water in, 90, 101.
Lava, absorption of water by:
Arizona, 428.
Idaho, 473.
Oregon, 289.
Lava, occurrence of water in, 105, 473, 480, 481, 482, 483.
Laws relating to underground waters:
Laws authorizing artesian investigations, 374.
Laws governing artesian investigations, 572.

Laws relating to underground waters—Cont'd.
Laws needed, 488.
Laws on underground waters, 179, 248.
Legal decisions, 30.
Leona formation, occurrence of water in, 569.
Limestone, absorption of water by:
New York, 455.
Montana, 461.
Limestone, occurrence of water in, 5.
Lower magnesian limestone, occurrence of water in, 556.
Louisiana.
Brines, 226, 235.
Mineral waters, production of. See Mineral waters.
Principal survey publications:
Rice irrigation in southern Louisiana, 165.
Underground waters of southern Louisiana, 210.
Water supplies from wells in southern Louisiana, 164.
Springs:
Descriptions, 392.
Quality, 392.
Temperature, 392.
Uses, 392, 406.
Yield, 392, 406.
Underground waters:
Descriptions, 164, 210, 226.
Origin, 210.
Use for water supplies, 164.
Water horizons.
Wells:
Analyses, 210.
Construction and drilling, 210, 226.
Descriptions, 164, 165, 226.
Discharge, variations in, 210.
Pumping from, 210.
Quality, 164, 210.
Records, 210, 226.
Temperature, 95, 165.
Thermal, 226.
Uses:
Irrigation, 165.
Public supplies, 164.
Work of U. S. Geological Survey, 167, 471, 572, 580.
Machinery, pumping. See Pumping machinery.
Maine.
Mineral waters, production of. See Mineral waters.
Principal survey publication:
Well and spring records, 18.
Springs:
Analyses, 18, 392.
Descriptions, 18, 392.
Erosion by, 524.
Quality, 18, 392.
Temperature, 18, 392.
Uses, 18, 392, 406.
Yield, 18, 392, 406.
Underground water conditions, 18.
Wells:
Analyses, 18.
Descriptions, 18.
Temperature, 18.
Maine—Continued.
Wells—Continued.
Uses, 18.
Yield, 18.
Work of U. S. Geological Survey, 167, 580.
Marshall sandstone, occurrence of water in, 280.
Maryland.
Mineral waters, production of. See Mineral waters.
Principal survey publications:
Artesian water prospects in the Atlantic Coastal Plain, 86.
Nomini folio, 87.
Washington folio, 94.
Springs:
Analyses, 392.
Description, 65, 392.
Quality, 392.
Temperature, 392.
Uses, 392, 406.
Yield, 392, 406.
Underground waters, description, 78, 86, 87 94, 320, 335.
Water horizons, 86, 87, 94, 574, 576.
Wells:
Descriptions, 86, 87, 94.
Records, 86, 94.
Temperature, 86.
Massachusetts.
Mineral waters, production of. See Mineral waters.
Principal survey publications:
Additional well records in Massachusetts, 47.
Well and spring records, 73.
Springs:
Analyses, 73, 139, 392.
Descriptions, 73, 139, 392, 492, 493, 496, 626.
Quality, 73, 392.
Temperature, 73, 392.
Uses, 73, 392, 406.
Yield, 73, 392, 406.
Underground water conditions, 73, 493.
Wells:
Analyses, 61, 73, 140.
Cost, 47.
Descriptions, 47, 73, 496.
Occurrence on faults, 140.
Quality, 73.
Records, 73, 139, 627.
Temperature, 73.
Uses, 73.
Yield, 47, 73.
Work of U. S. Geological Survey, 167, 580.
Matawan formation, occurrence of water in, 16, 86.
Measurement of discharge of wells and springs. See Discharge.
Measurement of underflow, 500, 578.
Measurement of underflow, instruments for, 500.
Medina sandstone, occurrence of water in, 380.
Metamorphism by underground waters, 565.
Michigan.
Absorption of streams by limestone, 371.
Absorption of water by sinks, 364.
Brines, 112, 280, 448, 451, 532, 616, 619.

Michigan—Continued.
Mine waters, 67.
Mineral waters, production of. See Mineral waters.
Ore deposits, part of underground waters in formation of, 17, 66, 67, 299, 515, 562, 568.
Principal Survey publications:
Lower Michigan mineral waters, 280.
Water resources of the lower peninsula, 279.
Well and spring records, 71.
Sinks, 364.
Springs:
Analyses, 71, 280, 392.
Descriptions, 71, 392.
Quality, 71, 392.
Temperature, 71, 392.
Uses, 71, 392, 406.
Yield, 71, 406.
Underground waters:
Chemistry, 280.
Descriptions, 71, 279, 280, 371.
Economic value, 280.
Temperature, 279.
Uses, 279.
Work of solution, 364.
Water horizons, 279, 280.
Wells:
Analyses, 71, 280.
Descriptions, 71.
Quality, 71.
Records, 71.
Temperature, 71, 95, 279.
Uses, 71.
Yield, 71.
Work of U. S. Geological Survey, 167, 279, 280, 574, 576, 578, 580.
Minnekahta formation, occurrence of water in, 98, 103.
Minnelusa formation, occurrence of water in, 93.
Mine waters.
Deposits, Colorado, 144.
Descriptions:
Arizona, 463.
California, 312.
Colorado, 144, 318, 447, 461.
Illinois, 12.
Michigan, 67.
Minnesota, 296.
Nevada, 19, 20, 324.
Pennsylvania, 33, 294.
Utah, 26, 27, 28, 549.
Vermont, 598.
Wyoming, 517.
Use for water supply, 26, 27.
Mineral waters.
Bibliography, 216, 217.
Economic products of:
Bromine, 111, 118.
Iodine, 109.
Potassium salts, 120.
Production in the United States, 113, 114, 115, 116, 119, 390, 391, 393, 394, 395, 398, 402, 403, 404, 405, 407, 409, 410, 411, 412, 413, 414, 415, 416, 417, 431, 432, 433, 434, 436, 438, 439, 441, 572, 573, 574, 575, 576, 577, 578, 578a, 580, 618, 620.
Minnesota.
Brines, 560.
Mine waters, 296
Mineral waters, production of. See Mineral waters.
Ore deposits, part of underground waters in formation of, 69, 296, 563.
Principal Survey publications:
Well and spring records, 207.
Well records in Lyon County, 546.
Springs:
Analyses, 207, 392.
Descriptions, 207, 392, 560.
Quality, 207, 392.
Temperature, 207, 392.
Uses, 207, 392, 406.
Yield, 207, 392, 406.
Underground waters:
Circulation, 296.
Descriptions, 207, 437.
Wells:
Composition and quality, 207, 546.
Descriptions, 207, 546, 560.
Records, 207, 546, 559.
Temperature, 95.
Uses, 207.
Yield, 207, 546.
Work of U. S. Geological Survey, 167, 471, 580.
Miocene waters. See Underground waters, occurrence of, systems.
Mississippi.
Mineral waters, production of. See Mineral waters.
Principal Survey publication:
Well records, 266.
Springs:
Analyses, 392.
Descriptions, 392.
Quality, 392.
Temperature, 392.
Uses, 392, 406.
Yield, 392, 406.
Underground waters, 266.
Water horizons, 266.
Wells:
Descriptions, 210, 266.
Quality, 266.
Records, 501.
Yield, 266.
Mississippi Valley.
Ore deposits, part of underground waters in formation of, 76.
Underground waters.
Descriptions, 357.
Underflow measurements, 578.
Well statistics, 574.
Missouri.
Mineral waters, production of. See Mineral waters.
Ore deposits, part of underground waters in formation of, 5, 11, 64, 76, 510, 564, 625.
Principal Survey publications:
Water supply of Livingstone county, 211.
Well and spring records, 497.
Wells of Joplin and vicinity, 514.

Missouri—Continued.
Springs:
Analyses, 62, 63, 392, 497.
Descriptions, 1, 392, 497.
Composition and quality, 63, 392, 497.
Temperature, 392, 497.
Uses, 392, 406, 497.
Yield, 392, 406, 497.
Underground waters:
Circulation, 11.
Descriptions, 211, 335, 497.
Water horizons, 328.
Wells:
Analyses, 60, 514.
Descriptions, 497.
Quality, 497.
Records, 211, 497, 514, 625.
Temperature, 95, 497.
Uses, 497.
Yield, 497.
Work of U. S. Geological Survey, 167, 471, 580.
Molokai.
Principal Survey publication:
Water resources of Molokai, 314.
Springs, 314.
Underground waters, 314.
Wells:
Composition, 314.
Description, 314.
Use for irrigation, 314.
Monmouth formation, occurrence of water in, 16.
Montana.
Absorption of streams, 10, 586, 591, 593, 594.
Absorption of water by limestone, 336.
Brines, 616, 619.
Caverns, 586.
Mineral waters, production of. See Mineral waters.
Ore deposits, part of underground waters in formation of, 588, 596.
Principal Survey publication:
Formation of travertine and siliceous sinter, 584.
Seepage, 336, 343.
Springs. See also Thermal springs:
Analyses, 53, 392.
Composition, 145, 392, 591.
Deposits, 145, 261, 588, 589, 590, 595, 597.
Descriptions, 145, 285, 291, 317, 392, 472, 586, 591.
Temperature, 392.
Uses:
Bathing, 594.
Resorts, 406, 586, 594.
General, 392.
Work of:
In altering rocks, 595.
General, 145.
Yield, 406.
Thermal springs and geysers:
Analyses, 54, 55, 594.
Composition, 591.
Descriptions, 145, 354, 408, 577, 586.
Relations to igneous rocks, 145, 586, 595.
Underground waters:
Descriptions, 472, 593.
Work of solution, 586.
Water horizons, 453.
Montana—Continued.
Wells:
Descriptions, 593.
Temperature, 95.
Work of U. S. Geological Survey, 145, 439, 577.
Mud cones, etc., 626.
Myricks formation, occurrence of water in, 569.
Natural wells, North Carolina, 77.
Nebraska.
Absorption of water, 100, 529.
Brines, 4, 14, 619.
Mineral waters, production of. See Mineral waters.
Principal Survey publications:
Camp Clarke folio, 100.
Edgemont folio, 103.
Groundwater at Kearney, 528.
Underground waters in southeastern Nebraska, 91.
Water resources of Patrick and Goshen Hole quadrangles, 4.
Water resources west of the one hundred and third meridian, 90, 99.
Wells and windmills, 14.
Sinks and caves, 103.
Springs:
Deposits, 103.
Descriptions, 4, 14, 90, 100, 101, 393.
Measurements, 254.
Thermal, 98.
Use for resorts, 406.
Yield, 406.
Underground waters:
Descriptions, 4, 14, 90, 91, 98, 100, 101, 103, 362, 437.
Work of solutions, 103.
Water horizons, 4, 90, 91, 98, 100, 103.
Wells:
Analyses, 103.
Breathing, 14.
Cost, 345.
Description, 91, 346.
Fluctuation, 528.
Problems, 579.
Pumping by windmills, 14.
Records, 4, 14, 31, 103, 345.
Salt, 14.
Statistics, 345.
Temperature, 96, 575.
Uses:
Irrigation, 90, 91.
Town supplies, 14.
Work of the U. S. Geological Survey, 104, 353, 355, 374, 440, 573, 574, 578, 580.
Nevada.
Absorption of streams, 373.
Brines, 112, 616.
Caves and solution fissures, 197.
Mine waters, 19, 20, 324.
Mineral waters, production of. See Mineral waters.
Ore deposits, part of underground waters in formation of, 20, 21, 22, 76, 197, 522, 595.
Springs:
Analyses, 53, 392, 476.
Composition, 392, 477.
Deposits, 7, 476.
Descriptions, 374, 392, 476, 584.

Nevada—Continued.
Springs—Continued.
Measurements, 251.
Occurrence on faults, 476.
Sulphur, 110.
Temperature, 392, 476.
Uses, 392.
Yield, 392.
Thermal springs:
Deposits, 522.
Descriptions, 7, 21, 22, 427, 476, 521, 522.
Underground waters, work of. See also Ore deposits.
Cementation, 522.
Oxidation, 522.
Solution, 197.
Newark formation, occurrence of water in, 444.
New Hampshire.
Mineral waters, production of. See Mineral waters.
Principal Survey publication:
Well and spring records, 29.
Springs:
Analyses, 29.
Descriptions, 29.
Quality, 29.
Temperature, 29.
Uses, 29, 406.
Yield, 29, 406.
Underground water conditions, 29.
Wells:
Analyses, 29, 392.
Descriptions, 29, 392.
Quality, 29, 392.
Temperature, 29, 392.
Uses, 29, 392.
Yield, 392.
Work of the U. S. Geological Survey, 167, 580.
New Jersey.
Mineral waters, production of. See Mineral waters.
Principal Survey publications:
Artesian-well prospects in the Atlantic Coastal Plain, 86.
Springs:
Analyses, 392.
Descriptions, 392.
Quality, 392.
Temperature, 392.
Use, 392.
Yield, 392.
Underground waters, 86, 444.
Water horizons, 86.
Wells, 86, 444.
Analyses, 392.
Descriptions, 86, 444.
Records, 77, 86, 613.
Temperature, 86.
Work of U. S. Geological Survey, 167, 439, 471, 580.
Newman formation, occurrence of water in, 34, 35.
New Mexico.
Mineral waters, occurrence of, 234.
Mineral waters, production of. See Mineral waters.
Principal Survey publication:
Irrigation in Mesilla Valley, 15.
New Mexico—Continued.
Sinks in gypsum, 234.
Springs:
Analyses, 55, 59, 64, 392.
Descriptions, 392, 466.
Quality, 392.
Temperature, 392.
Uses, 392, 406.
Yield, 392, 406.
Underground waters:
Composition, 234.
Descriptions, 15, 234, 466.
Work of solution, 234.
Wells:
Composition, 234, 429.
Description, 234, 346, 429.
Work of the U. S. Geological Survey, 104, 580.
New York.
Absorption of water by limestone, 455.
Brines, 112, 448, 449, 450, 451, 616, 619.
Mineral waters, production of. See Mineral waters.
Principal Survey publications:
Sewage pollution in the Metropolitan area, 292.
Water resources, 454, 455.
Springs:
Analyses, 64, 392.
Brine, 448, 449, 450, 451.
Description, 392, 454, 610.
Quality, 392, 610.
Temperature, 392, 610.
Uses, 392, 406, 610.
Yield, 392, 406, 610.
Streams, underground, 456.
Underground waters, 444, 456, 610.
Water horizons, 86, 249, 580.
Wells:
Analyses, 610.
Brines, 112.
Descriptions, 86, 444, 455, 610.
Quality, 610.
Records, 86, 610.
Temperature, 86, 610.
Uses, 610.
Yield, 610.
Work of the U. S. Geological Survey, 167, 471.
New Zealand springs, 584.
Niagara limestone, occurrence of water in, 43, 371, 556.
Niobrara formation, occurrence of water in, 441, 545.
North Carolina.
Absorption of streams, 371.
Mineral waters, production of. See Mineral waters.
Natural wells, 77.
Principal Survey publications:
Artesian-well prospects in the Atlantic Coastal Plain, 86.
Norfolk folio, 97.
Sinks, 443.
Springs:
Analyses, 60, 392.
Descriptions, 269, 270, 274, 347, 371, 392, 442, 443.
Quality, 392.
Temperature, 392.

North Carolina—Continued.
Springs—Continued.
Uses, 392, 406.
Yield, 392, 406.
Underground waters:
Descriptions, 86, 97.
Work of solution, 443.
Water horizons, 86, 97.
Well prospects and records, 86, 97.
North Dakota.
Brines, 560.
Mineral waters, production of. See Mineral waters.
Springs, 538, 560.
Wells:
Descriptions, 346, 437.
Records, 538.
Work of U. S. Geological Survey, 104, 572, 573, 574, 576, 578, 580.
Ogallala formation, occurrence of water in, 90.
Ohio.
Brines:
Analyses, 449.
Descriptions, 108, 379, 449, 616, 619.
Mineral waters, production of. See Mineral waters.
Principal Survey publications:
Natural features and economic development of the Sandusky, Maumee, Muskingon, and Miami drainage areas, 152.
Water resources of Indiana and Ohio, 302.
Springs:
Analyses, 392.
Descriptions, 301, 392.
Quality, 392.
Temperature, 392.
Uses, 392, 406.
Yield, 392, 406.
Subterranean drainage, 301.
Underground waters:
Analyses, 301.
Description, 301, 419, 437.
Use for public supplies, 152, 301.
Water horizons, 301, 380.
Wells:
Brine, 449.
Description, 152, 306, 380, 628.
Lists, 185.
Records, 38, 419, 468.
Work of U. S. Geological Survey, 574.
Oil and gas, relation of underground waters to, 3, 150, 226, 422, 436, 525.
Oklahoma.
Wells, descriptions of, 346.
Work of the U. S. Geological Survey, 104, 580.
Oligocene waters. See Underground waters, occurrence of, systems.
Onondaga formation, occurrence of water in, 380.
Ore deposits, part of underground waters in formation of—
General relations, 565.
Localities:
Alabama, 225.
Alaska, 325.
Arizona, 462, 463, 463a, 465.
Arkansas, 5, 6, 11, 223, 564.
California, 22, 308, 595.
Colorado, 141, 142, 144, 414, 447, 460, 461, 519.
Ore deposits, part of underground waters in formation of—Continued.
Localities—Continued.
Georgia, 218, 221, 225, 228, 230.
Idaho, 311.
Illinois, 12, 13.
Iowa, 332.
Kansas, 510.
Kentucky, 511.
Lake Superior, 297, 563.
Michigan, 17, 66, 67, 299, 362, 515, 562.
Minnesota, 69, 296, 563.
Mississippi Valley, 76.
Missouri, 11, 76, 510, 564, 625.
Montana, 588, 596.
Nevada, 21, 22, 76, 197, 522, 595.
Pacific coast, 21, 22.
South Dakota, 147, 262.
Tennessee, 218, 220, 221, 224, 232, 275.
Utah, 143, 298, 518, 520, 549, 575.
Wyoming, 517.
General, 5, 565.
Oregon.
Absorption of streams by lava, 289.
Absorption of water by pumice and lava, 289.
Mineral waters, production of. See Mineral waters.
Principal Survey publications:
Artesian basins of southwestern Idaho and southeastern Oregon, 486, 487, 488.
Geological reconnaissance in southern Oregon, 475.
Nampa folio, 315.
Springs, common and thermal
Analyses, 313, 392, 427.
Deposits, 313, 427.
Descriptions, 281, 288, 289, 313, 315, 392, 427, 475, 487, 612.
Occurrence on faults, 475.
Temperature, 392, 406.
Thermal, 281, 288, 427, 443, 475, 612.
Uses, 392, 406.
Yield, 392, 406.
Underground channels, 123.
Underground waters:
Descriptions, 374, 487, 488.
Uses, 487.
Wells:
Descriptions, 315.
Problems, 579.
Records, 315.
Work of U. S. Geological Survey, 104, 580.
Oxidation by underground waters, 522.
Pacific coast. See also under State entries.
Ore deposits, part of underground waters in formation of, 21, 22.
Pahasapa formation, occurrence of water in, 102.
Paluxy formation, occurrence of water in, 242.
Pamunkey formation, occurrence of water in, 75, 85, 86.
Payette formation, occurrence of water in, 310.
Pennsylvania.
Brines, 585.
Mine waters:
Analyses, 294.
Descriptions, 33, 294.
Mineral waters, production of. See Mineral waters.

Pennsylvania—Continued.
Principal Survey publications:
Artesian well prospects in the Atlantic coastal plain, 86.
Quality of water in the Susquehanna River drainage basin, 294.
Water resources of the Philadelphia district, 16.
Springs:
Analyses, 294, 392.
Descriptions, 294, 392.
Quality, 392, 406.
Temperature, 392.
Uses, 392, 406.
Yield, 392.
Underground waters:
Descriptions, 16, 41, 42, 43, 294.
Use for public supplies, 467.
Water horizons, 16, 86.
Well incrustation, analysis of, 55.
Wells:
Analyses, 294.
Descriptions, 89, 160, 467.
Records, 41, 42, 43, 44, 160, 161, 163, 467, 468, 614.
Temperature, 96.
Uses, 467.
Permeability of rocks, 500.
Petrefaction by underground waters, 480.
Philippine Islands.
Hot Springs and solfataras, 24.
Pierre shales, occurrence of water in, 90, 547.
Pleistocene waters. See Underground waters, occurrence of, systems.
Poison Canyon formation, occurrence of water in, 245, 246.
Porosity.
Rocks, 277, 499, 500, 565.
Sands, 362, 453, 456, 499, 500.
Soil, 277, 362, 499, 500.
General, 277, 341, 362, 500, 565.
Porto Rico.
Springs, common and thermal.
Analyses, 241.
Composition, 241.
Descriptions, 241.
Use for bathing, 241.
Potassium salts from mineral waters, 120.
Potomac formation, occurrence of water in, 78, 86, 94, 328.
Potsdam formation, occurrence of water in, 6, 9, 381, 500, 556.
Power, use of springs and pumps for. See Uses of springs and wells.
Public supplies from underground sources.
Georgia, 327.
Louisiana, 164.
Nebraska, 14.
Ohio, 152.
Pennsylvania, 467.
Vermont, 420.
Pumice, absorption of water by, in Oregon, 289.
Pumping and other methods of lifting water.
Cost, 320, 356.
Descriptions:
Arizona, 106, 282, 283.
California, 49, 187, 208, 251, 320, 321, 322, 356.
Pumping and other methods of lifting water—Continued.
Descriptions—Continued.
Georgia, 362.
Great Plains, 72.
India, 621, 624.
Kansas, 375.
Louisiana, 210.
Nebraska, 14.
Public lands, 346.
Texas, 252.
United States, 343.
General, 14, 277, 526, 527, 622, 628.
Pumping machinery.
Efficiency, 15.
Types, 250.
Turbines, 14.
Windmills, descriptions and use of, 14, 338, 339, 340, 357, 358, 360, 421.
Quality of waters. See Composition.
Quaternary waters. See Underground waters, occurrence of, systems.
Rainfall, absorption of, 149, 454.
Rancocas formation, occurrence of water in, 86.
Raritan formation, occurrence of water in, 21, 35, 59.
Records.
Geologic:
Borings and wells:
Alabama, 501, 502.
Arizona, 283, 463.
Arkansas, 446.
California, 208, 307.
Delaware, 77.
District of Columbia, 86, 94.
Florida, 77, 169.
Georgia, 86.
Idaho, 315.
Illinois, 9, 37.
Indiana, 37, 158, 159, 303, 304, 305, 422.
Iowa, 31, 332.
Kentucky, 177.
Louisiana, 210, 226,
Massachusetts, 73, 139, 627.
Maryland, 86.
Michigan, 71.
Minnesota, 207, 546, 559.
Mississippi, 501.
Missouri, 211, 497, 514, 625.
Nebraska, 4, 14, 31, 103, 345.
New Jersey, 77, 86, 613.
New York, 86, 610.
North Carolina, 86, 97.
North Dakota, 538.
Ohio, 38, 306, 419, 468.
Oregon, 315.
Pennsylvania, 41, 42, 43, 44, 160, 161, 163, 467, 468, 614.
Rhode Island, 153, 627.
South Dakota, 102, 103, 538, 539, 541, 542, 543, 544.
Tennessee, 176.
Texas, 2, 226, 568.
Vermont, 420,
Virginia, 86, 97, 154, 468, 479, 613.
Washington, 480.
Western Gulf coast, 3.
Western interior, 2.

Records—Continued.
Geologic—Continued.
Borings and wells—Continued.
West Virginia, 38, 39, 40, 468.
Wyoming, 23, 102.
General:
Importance of, 45.
Interpretation of, 45.
Statistical:
Springs:
Eastern United States (see also under States), 334.
Wells:
California, 320.
Colorado, 345.
Eastern United States (see also under States), 334.
Kansas, 345.
Mississippi Valley, 574.
United States, 95, 96.
General, 322, 323.
Redbank formation, occurrence of water in, 78.
Relation of underground waters to oil and gas, 3, 185, 186, 333, 379, 422.
Resorts, use of springs for, 392, 406, 586, 594.
Rhode Island.
Mineral waters, production of. See Mineral waters.
Principal Survey publication.
Well and spring records, 74.
Springs:
Analyses, 74, 392.
Deposits, mud cones, 495.
Descriptions, 74, 392, 626.
Quality, 74, 392.
Temperature, 74, 392.
Uses, 74, 392.
Yield, 74, 392.
Wells:
Analyses, 74.
Descriptions, 74.
Quality, 74.
Records, 153, 627.
Temperature, 74.
Uses, 74, 406.
Yield, 74, 406.
Work of U. S. Geological Survey, 167, 580.
Rio Grande basin, absorption of streams, 437.
Rocks, absorption of water by, general.
California, 286.
Colorado, 529.
Rocky Mountains, sulphur springs, 617.
Rutledge limestone, occurrence of water in, 270, 271, 273.
St. Peter sandstone, occurrence of water in, 9, 556.
Salt, deposit of, from springs, 555.
Salt from mineral waters, 381, 382, 383, 384, 385, 386, 387, 388, 389, 616.
Sand, occurrence of water in (see also Drift), 529.
Sanitary aspects of underground waters, 293.
Seepage.
Arizona, 98, 101, 190, 362.
California, 188, 320, 322.
Seepage—Continued.
Colorado, 142, 149, 257, 345, 362.
Idaho, 105.
India, 621, 624.
Montana, 336, 343.
Nebraska, 4, 101, 347.
Public lands, 346.
Utah, 155, 347, 352.
Wyoming, 4.
General, 155, 347, 352.
Shale, occurrence of water in, 5, 453.
Siliceous sinter. See Deposits, springs.
Silicification by underground waters, 519.
Silurian waters. See Underground waters, occurrence of, springs.
Sinks. See Solution, sinks.
Sinks, absorption of water by, 496, 500.
Sioux quartzite, occurrence of water in, 543, 544.
Solfataras. See Springs, solfataras.
Solution by underground waters, work of.
Basins, 483.
Caves and caverns:
California, 551, 554.
Colorado, 141.
Iowa, 332.
Kentucky, 34, 35.
Montana, 586.
Nebraska, 103.
Nevada, 197.
South Dakota, 103.
Tennessee, 232.
Texas, 240, 569.
General, 494.
Channels:
Kentucky, 34, 35, 557.
Tennessee, 232.
Washington, 377.
General, 222.
Coves, 219.
Fissures, Nevada, 197.
Sinks:
Florida, 77.
High Plains, 267.
Kansas, 215.
Kentucky, 34, 35.
Michigan, 364.
Nebraska, 103.
New Mexico, 234.
North Carolina, 443.
South Dakota, 103.
Tennessee, 232, 270, 273.
Virginia, 92.
West Virginia, 88, 92.
General:
Solution of dolomite, Colorado, 519.
Wyoming, 151.
South Carolina.
Craterlets and springs associated with the Charleston earthquake, 130.
Mineral waters, production of. See Mineral waters.
Principal Survey publication:
Artesian prospects of the Atlantic Coastal Plain, 86.
Sinks and caves, 108.

South Carolina—Continued.
Springs:
Analyses, 392.
Descriptions, 392.
Quality, 392.
Temperature, 392.
Uses, 392, 406.
Yield, 392, 406.
Underground waters, 86.
Water horizons, 86.
Wells:
Descriptions, 86.
Temperature, 86.
South Dakota.
Brines, 102, 619.
Mineral waters, production of. See Mineral waters.
Ore deposits, part of underground waters in formation of, 147, 262.
Principal Survey publications:
Alexandria folio, 544.
Edgemont folio, 103.
Geology and water resources of part of the lower James River Valley, 206.
Huron folio, 547.
Mitchell folio, 543.
Newcastle folio, 102.
New developments in well boring and irrigation, 89.
Oelrichs folio, 98.
Olivet folio, 541.
Parker folio, 542.
Water resources in Black Hills and in Wyoming, 98.
Water resources of southeastern South Dakota, 540.
Sinks and caves, 103.
Springs:
Analyses, 89.
Composition, 539.
Deposits, 103.
Descriptions, 93, 538, 539, 540, 541, 542, 544, 547.
Uses, 406.
Yield, 406.
Underground waters:
Descriptions, 89, 93, 102, 103, 374, 540, 542, 543, 544, 545, 547.
Occurrence as streams, 182.
Waste of, 545.
Water horizons, 93, 102, 103, 539, 541, 542, 543, 544, 545, 547.
Wells:
Analyses, 89, 102, 103.
Descriptions, 89, 93, 346, 437.
Fluctuations, 540.
Interference, 540.
Pressure in, 89.
Pressure, decline of, 545.
Records, 102, 103, 538, 539, 541, 542, 543, 544.
Temperature, 89, 96, 541.
Uses:
Supply for lake, 89.
Irrigation, 89.
Work of U. S. Geological Survey, 104, 357, 361, 439, 440, 573, 574, 576, 577, 578, 580.

Springs.
Classification, 392, 406.
Descriptions:
Geysers. See Geysers.
Hot springs. See Springs, description, thermal.
Springs in general—
Localities:
Alabama, 204, 392.
Alaska, 70, 325, 392, 498.
Arizona, 127, 128, 290, 317, 392, 469a, 528.
Arkansas, 1, 59, 392, 446.
California, 22, 67, 105, 121, 134, 146, 170, 251, 286, 307, 308, 312, 319, 321, 392, 458, 477, 533, 558.
Canada, Manitoba, 560.
Cascade Mountains, 129.
Colorado, 60, 75, 137, 141, 142, 244, 264, 357, 362, 392, 435, 447, 461, 516.
Connecticut, 183, 247, 392, 500.
Dakotas, 392.
Delaware, 392.
Eastern United States, 334, 335, 392.
Florida, 77, 169, 203, 392, 434.
Georgia, 105, 202, 214, 253, 324, 392.
Great Plains, 214.
High Plains, 267.
Idaho, 284, 310, 311, 317, 392, 473, 482, 483, 484, 485, 487, 488, 523.
Illinois, 292.
Indiana, 159, 161, 162, 300, 301, 392.
Kansas, 184, 212, 215, 392, 445, 489.
Kentucky, 34, 35, 392.
Louisiana, 392.
Maine, 18, 392, 524.
Maryland, 87, 392.
Massachusetts, 78, 139, 392, 492, 498, 496, 626.
Michigan, 71, 280, 392.
Minnesota, 207, 392, 560.
Mississippi, 392.
Missouri, 1, 62, 63, 392, 497.
Molokai, 314, 392.
Montana, 53, 145, 261, 285, 291, 317, 392, 472, 586, 588, 589, 590, 591, 594, 595, 597.
Nebraska, 4, 14, 90, 98, 100, 101, 392.
Nevada, 7, 53, 110, 251, 374, 392, 476, 477, 547, 584.
New Hampshire, 29, 392.
New Jersey, 392.
New Mexico, 55, 59, 64, 392, 466.
New York, 64, 392, 448, 449, 450, 451, 454, 610.
North Carolina, 269, 270, 271, 274, 347, 371, 392, 442, 443.
North Dakota, 538, 560.
Ohio, 301, 392.
Oregon, 281, 288, 289, 313, 315, 392, 427, 475, 487, 612.
Pennsylvania, 16, 294, 392.
Philippines, 24.
Porto Rico, 241.
Rhode Island, 74, 392, 495, 626.

Springs—Continued.
Descriptions—Continued.
Springs in general—Continued.
Localities—Continued.
South Dakota, 89, 93, 103, 588, 539, 540, 541, 542, 544, 547.
South Apalachians, 442.
Tennessee, 61, 269, 270, 271, 274, 864, 392, 442, 443.
Texas, 239, 240, 243, 252, 254, 257, 260, 342, 347, 357, 372, 392, 536, 537, 568, 572.
Utah, 27, 56, 75, 170, 392, 504, 534, 549.
Vermont, 392, 420.
Virginia, 53, 54, 56, 87, 92, 154, 354, 392, 442.
Washington, 260, 354, 392, 425, 426, 505, 506, 507.
West Virginia, 92.
Wyoming, 4, 8, 93, 136, 151, 191, 192, 193, 194, 195, 196, 198, 201, 392.
Yellowstone National Park, 54, 57, 58, 178, 189, 190, 191, 192, 193, 194, 195, 198, 199, 200, 362, 392, 432, 433, 434, 583, 584, 587.
General papers:
Algus growth in, 193.
Beneath glaciers, 524.
Distribution in the United States, 406.
Contamination, 500.
Craterlets formed by springs:
Charleston earthquake, 130.
Rhode Island, 495.
Erosion by, Maine, 524.
Failure of, California, 533.
Geology of, 406.
Lists of, 390, 391, 392, 393, 394, 397, 398, 402, 403, 404, 405, 410, 411, 412, 413, 417.
Origin, 406.
Relation to igneous intrusions, 145, 586, 595.
Source of mineralization, 406.
Types of waters:
Alum, 34, 35,
Brine:
Arizona, 616.
Colorado, 616, 619.
Dakotas, 616.
Idaho, 616.
Illinois, 619.
Indiana, 619.
Kansas, 619.
Kentucky, 619.
Montana, 616, 619.
Nebraska, 619.
Nevada, 616.
New York, 448, 449, 616, 619.
Oregon, 616.
Pacific coast, 616.
South Dakota, 619.
Tennessee, 619.
United States, 616, 619.
Western Gulf coast, 3.
Chalybeate, Kentucky, 34, 35.
Springs—Continued.
Descriptions—Continued.
Springs in general—Continued.
Localities—Continued.
Oil and gas:
Alaska, 325.
Tennessee, 36.
Sulphur:
Alaska, 70.
Kentucky, 34, 35.
Nevada, 110.
Rocky Mountains, 617.
Tennessee, 272.
Wyoming, 136, 201.
Solfataras:
California, 121.
Utah, 110.
General, 24.
Thermal springs. See also Geysers, solfataras, and springs in general.
Descriptions:
California, 22, 121.
Colorado, 137, 142, 357.
Florida, 434.
Idaho, 309, 310, 311, 316.
Montana, 145, 354, 408, 586.
Nebraska, 54, 55, 98, 577, 591, 594, 595.
Nevada, 7, 21, 22, 427, 476, 521, 522.
Oregon, 281, 288, 313, 427, 475.
Philippine Islands, 24.
Porto Rico, 241.
Tennessee, 275.
Utah, 252.
Virginia, 92.
West Virginia, 92.
Wyoming, 136, 151, 201.
Work on, 57, 189, 190, 217, 432, 433, 434, 440.
General:
Occurrence on earthquake fissure, 477, 553.
Origin of thermal waters, 447.
Relation to igneous intrusions, 145, 586, 595.
Springs, deposits of. See Deposits.
Springs, discharge of. See Discharge.
Springs, mineral, production of. See Mineral waters.
Springs, relation to faults. See Faults.
Springs, relation to fissures. See Fissures.
Springs, relation to folds. See Folds.
Springs, relation to igneous intrusions. See Igneous intrusions.
Springs, statistics. See Mineral waters and springs, descriptions.
Springs, uses of. See Uses of underground waters.
Statistics.
Discharge. See Discharge.
Mineral water production. See Mineral waters, production of.
Mineral waters, work on, 401.
Necessity of, 370.
Springs. See Springs.
Wells. See Wells.
Streams, sinking and intermittent. See Absorption of streams.
Streams, underground, 182, 456.

Structures.
Collecting ditches, 283, 371.
Collecting galleries, 500, 622.
Collecting and drainage tunnels, 28, 287, 318, 323, 366, 622.
Infiltration works, 481.
Subsurface dams, 500, 622.
Underflow canal, 343.
Subsurface dams. See Structures.
Sucking wells. See Breathing wells.
Sulphur deposited by springs, 70, 121, 215.
Temperature.
Springs:
Alabama, 392.
Alaska, 392.
Arizona, 392.
Arkansas, 392; 446.
California, 392.
Colorado, 392.
Connecticut, 183, 392.
Dakotas, 392.
Delaware, 392.
Florida, 169, 392.
Georgia, 392.
Idaho, 392.
Illinois, 392.
Indiana, 392.
Indian Territory, 392.
Iowa, 392.
Kansas, 392.
Kentucky, 392.
Louisiana, 392.
Maine, 18, 392.
Maryland, 392.
Massachusetts, 73, 392
Michigan, 71, 392.
Minnesota, 207, 392.
Mississippi, 392.
Missouri, 392, 497.
Montana, 392.
Nebraska, 392.
Nevada, 392, 476.
New Hampshire, 29, 392.
New Jersey, 392.
New Mexico, 392.
New York, 392, 610.
North Carolina, 392.
Ohio, 392.
Oregon, 392.
Pennsylvania, 392.
Rhode Island, 74, 392.
South Carolina, 392.
Tennessee, 392.
Texas, 392.
United States, 392, 406.
Utah, 392.
Vermont, 392, 420.
Virginia, 392.
Washington, 392.
West Virginia, 392.
Wisconsin, 392.
Wyoming, 392.
Yellowstone National Park, 178, 190, 392.
General, 406.
Wells:
Alabama, 95, 502.
Arkansas, 95.
Temperature—Continued.
Wells—Continued.
California, 95.
Colorado, 95.
Connecticut, 183.
Delaware, 86.
District of Columbia, 86.
Florida, 95, 169.
Georgia, 86, 95.
Great Plains, 214.
Idaho, 95, 316, 484, 485.
Illinois, 95.
Iowa, 95.
Louisiana, 95.
Maine, 18.
Maryland, 86.
Massachusetts, 73.
Michigan, 71, 95, 279.
Minnesota, 95.
Mississippi, 95.
Missouri, 95, 479.
Montana, 95.
Nebraska, 96.
New Hampshire, 29.
New Jersey, 86, 96.
New York, 86, 610.
North Carolina, 86.
Pennsylvania, 96.
Rhode Island, 74.
South Carolina, 86, 96.
South Dakota, 89, 96, 541.
Tennessee, 96.
Texas, 96.
United States, 95, 96.
Virginia, 86, 96.
Washington, 96, 480, 505.
West Virginia, 63, 171, 172, 439, 440, 574.
Wisconsin, 96.
General, 45.
General papers:
Causes of temperature—
Igneous action, 477.
General, 475.
Effect on water level, 565.
Mine waters—
Comstock lode, Nevada, 19, 20.
Temperature work in Nevada, 575.
Temperature work in West Virginia, 63, 171, 172, 439, 440, 574.
Tennessee.
Absorption of streams by underground channels, 219.
Brines, 619.
Mineral waters, production of. See Mineral waters.
Ore deposits, part of underground waters, in formation of, 218, 220, 221, 224, 232, 275.
Principal Survey publication:
Well records, 176.
Sinks, caves, etc., 232, 270, 271, 273.
Springs:
Analyses, 61, 364, 392.
Descriptions, 269, 270, 271, 274, 364, 392, 442, 443.
Oil springs, 36.
Quality, 392.
Temperature, 392.

Tennessee—Continued.
Springs—Continued.
Thermal springs in limestone, 275.
Use:
Power, 442.
General, 392, 406.
Yield, 392, 406.
Underground channels, 222, 272, 273, 442.
Underground waters:
Circulation, 272.
Descriptions, 176.
Occurrence, 272, 273, 442.
Work of:
Formation of coves, 219.
Solution, 232.
Water horizons, 202, 207.
Wells:
Descriptions, 176.
Quality, 176.
Records, 176.
Temperature, 96.
Uses, 176.
Yield, 176.
Work of U. S. Geological Survey, 167, 580.
Tertiary waters. See Underground waters, occurrence of, systems.
Testing of wells. See Wells.
Texas.
Absorption of streams, 99.
Brines, 226, 229.
Caves:
Deposits in, 236.
Descriptions of, 240, 569.
Mineral waters, production of. See Mineral waters.
Principal Survey publications:
Austin dam, 535.
Austin folio, 243.
Black and Grand prairies, 242.
Irrigation systems, 252, 536.
Nueces folio, 240.
Underground waters of the Edwards Plateau and Rio Grande Plain, 239.
Uvalde folio, 569.
Water powers of Texas, 537.
Springs:
Analyses, 392.
Deposits:
Analyses, 260.
Descriptions, 260.
Descriptions, 240, 242, 243.
Measurements, 252, 254, 257, 260, 347, 357, 372, 392, 536, 537, 568, 572.
Occurrence on:
Faults, 239, 240, 569.
Fissures, 239.
Quality, 392.
Temperature, 392.
Use:
Irrigation, 536, 537.
Power, 357, 536, 537, 569.
Resorts, 406.
General, 392.
Yield, 392, 406.
Underground streams, 243, 342, 456.
Texas—Continued.
Underground waters:
Chemistry and composition, 236, 242.
Descriptions, 229, 232, 238, 239, 242, 270, 273, 437, 575.
Work of solution, 240, 569.
Water horizons, 239, 240, 242, 243, 569.
Wells:
Analyses, 239.
Composition, 236, 242.
Drilling, 226.
Descriptions, 226, 252, 254, 257, 342, 346, 537, 568.
Experiments, 237.
Pumping for irrigation, 252.
Records, 2, 226, 568.
Temperature, 96.
Thermal, 226.
Use for irrigation, 252, 536.
Work of U. S. Geological Survey, 104, 439, 572, 573, 574, 577, 580.
Therapeutics. See Uses of underground waters.
Travertine. See Deposits, springs.
Travis Peak formation, occurrence of water in, 239.
Trenton limestone, occurrence of water in, 292, 379, 380, 422.
Trinity formation, occurrence of water in, 99, 240, 242.
Tufa deposits. See Deposits, springs.
Underflow canals, 343.
Underflow, instruments for measuring, 500.
Underflow, measurement of, 500, 578.
Underground water.
Depth, limits of, 500, 561, 565.
Effect of irrigation on level of, 156, 187, 188.
Effect of uplift and subsidence on, 565.
Influence on floods, 341.
Laws relating to, 30, 179, 248, 357, 374, 572.
Movements of:
Flow in porous media, 277, 499, 500.
In fissures, 277.
Underflow in Arizona, 283.
Occurrence of:
Formations:
Arikaree:
Nebraska, 4, 90, 101.
Benton:
Montana, 588.
South Dakota, 543, 544, 545.
Berea grit:
Michigan, 280.
Blackwater hole beds, Texas, 240.
Brule clays:
Nebraska, 4, 90, 101
Wyoming, 4.
Calaveras:
California, 554.
Chadron:
Nebraska, 90.
Chattanooga shale:
Tennessee, 272.
Chesapeake:
Atlantic Coastal Plain, 86.
Delaware, 86.
Maryland, 86, 87.

Underground water—Continued.
Occurrence of—Continued.
Formations—Continued.
Chesapeake—Continued.
New Jersey, 86.
Virginia, 86, 87.
Chester Valley limestone:
Pennsylvania, 16.
Chickies quartzite:
Pennsylvania, 16.
Clinton:
Ohio, 380.
Columbia:
Atlantic Coastal Plain, 86.
Delaware, 86.
District of Columbia, 94.
Maryland, 78, 86, 87, 94.
North Carolina, 97.
South Carolina, 86.
Virginia, 78, 86, 87, 94, 97.
Comanche Peak:
Texas, 240.
Corniferous limestone:
Ohio, 380.
Corsicana:
Texas, 242.
Cretaceous marl:
Delaware, 86.
Dakota sandstone:
Colorado, 173, 174, 175, 244, 245, 246.
Dakotas, 84, 93.
Kansas, 212, 213.
Minnesota, 560.
Nebraska, 90, 91, 98, 100, 101, 103.
North Dakota, 560.
South Dakota, 93, 102, 103, 539, 541, 542, 543, 544, 545, 547.
Wyoming, 102.
General, 354, 500, 613.
Denison:
Texas, 242.
Devonian limestone:
Illinois, 556.
Edwards limestone:
Texas, 239, 240, 242, 243, 569.
Galena limestone:
Illinois, 556.
Iowa, 332.
Gering:
Nebraska, 90.
Glen Rose:
Texas, 242, 569.
Hudson River shales:
Illinois, 556.
John Day:
Washington, 480.
Knox dolomite:
North Carolina, 269, 270, 271, 272, 273.
Tennessee, 269, 270, 271, 272, 273.
Lafayette:
Atlantic Coastal Plain, 86.
Maryland, 78, 86, 87.
South Carolina, 86.
Virginia, 78, 86, 87.
Lakota sandstone:
Nebraska, 103.
South Dakota, 102, 103.
Underground water—Continued.
Occurrence of—Continued.
Formations—Continued.
Lakota sandstone—Continued.
Wyoming, 102.
General, 93.
Laramie:
Nebraska, 90, 101.
Leona:
Texas, 569.
Lower Magnesian limestone:
Illinois, 556.
Magothy:
Maryland, 86.
Manasquan:
New Jersey, 86.
Marshall:
Michigan, 280.
Matawan:
Atlantic Coastal Plain, 86.
New Jersey, 86.
Pennsylvania, 16.
Medina:
Ohio, 380.
Middle marl:
Atlantic Coastal Plain, 86.
Minnekahta:
Nebraska, 98, 103.
South Dakota, 103.
Minnelusa:
South Dakota, 93.
Monmouth:
Pennsylvania, 16.
Myrick:
Texas, 569.
Navesink:
New Jersey, 86.
Newark:
New Jersey, 444.
Newman:
Kentucky, 34, 85.
Niagara limestone:
Illinois, 556.
Indiana, 379.
Ohio, 379, 380.
Niobrara:
South Dakota, 541, 545.
Ogallala:
Nebraska, 90.
Ohio shale:
Ohio, 380.
Onondaga:
Ohio, 380.
Pahasapa:
South Dakota, 102
Wyoming, 102.
Paluxy:
Texas, 242.
Pamunkey:
Atlantic Coastal Plain, 86.
Delaware, 86.
Maryland, 78, 86, 87.
Virginia, 78, 86, 87.
Fayette:
Idaho, 310.

Underground water—Continued.
Occurrence of—Continued.
Formations—Continued.
Pierre shales:
Nebraska, 90.
South Dakota, 547.
Poison Canyon:
Colorado, 245, 246.
Potomac:
Atlantic Coastal Plain, 86.
Delaware, 86.
District of Columbia, 94.
Maryland, 78, 86, 94, 328.
North Carolina, 97.
South Carolina, 86.
Virginia, 78, 86, 94, 97.
Potsdam sandstone:
Illinois, 9, 556.
Indiana, 9.
General, 500.
Rancocas:
Atlantic Coastal Plain, 86.
New Jersey, 86.
Raritan:
Delaware, 86.
New Jersey, 86.
Pennsylvania, 16.
Redbank:
Atlantic Coastal Plain, 86.
New Jersey, 86.
Rutledge limestone:
Tennessee, 270, 271, 273.
St. Peter sandstone:
Illinois, 9, 556.
Indiana, 9.
Severn:
Maryland, 86.
Shark River:
New Jersey, 86.
Sioux quartzite:
South Dakota, 543, 544.
Travis Peak:
Texas, 239.
Trenton limestone:
Illinois, 556.
Indiana, 379, 422.
Ohio, 379, 380.
Trinity:
Texas, 99, 240, 242.
Upper Heldeberg limestone:
Indiana, 379.
Ohio, 379.
Waverly:
Ohio, 380.
Wissahickon gneiss:
Pennsylvania, 16.
Woodbine:
Texas, 242.
Materials (see also Formations):
Alluvium:
Kansas, 215.
Nebraska, 101.
Utah, 549.
Andesite:
California, 458.
Basalt:
Texas, 569.
Underground water—Continued.
Occurrence of—Continued.
Materials—Continued.
Crystalline rocks:
Atlantic Coastal Plain, 86.
District of Columbia, 94.
General, 318.
Delta deposits:
California, 320, 328.
Dolomites:
Arkansas, 5.
Drift (see also Quaternary and Pleistocene):
Illinois, 9, 167, 300, 302, 305.
Indiana, 9, 162, 301, 303, 304, 305.
Minnesota, 560.
New York, 82, 249.
Ohio, 301, 380.
South Dakota, 547.
General, 45.
Dune sands:
Colorado, 174.
Granite:
Idaho, 310.
Gravel:
Arizona, 283.
California, 328.
Colorado, 174.
Massachusetts, 493.
General, 45, 277, 499, 500.
Igneous rocks:
California, 312.
Lava:
Arizona, 428.
Idaho, 473, 482, 483.
Oregon, 289.
Washington, 480, 481.
General, 105
Limestone:
Arkansas, 5.
General, 45.
Sand:
Nebraska, 529.
General, 45, 277, 499, 500.
Sandstone:
General, 45.
Serpentine:
New York, 249.
Shale:
Arkansas, 5.
Montana, 588.
Stream deposits:
California, 208.
Structures:
Earthquake fissures, 477, 553.
Faults, 140, 170, 239, 240, 247, 306, 475, 476, 477, 500, 553, 569.
Fissil rocks, 565.
Fissures, general, 239, 277, 284, 480.
Joints, 565, 568.
Underground channels, Oregon, 123.
Vesicules, 565.
Systems. See also Formations.
Silurian:
Michigan, 279, 280.
Devonian:
Michigan, 279, 280.

Underground water—Continued.
Occurrence of—Continued.
Systems—Continued.
Carboniferous:
Illinois, 162.
Indiana, 162.
Kansas, 215.
Michigan, 279.
Nebraska, 90.
Ohio, 380.
Cretaceous:
Great Plains, 214.
High Plains, 267.
Mississippi, 266.
Montana, 588.
Nebraska, 4.
New York, 86, 249.
South Carolina, 86.
Texas, 240, 242.
Wyoming, 4.
Tertiary:
Great Plains, 214.
High Plains, 267.
Kansas, 212, 213, 215.
Mississippi, 266.
Pennsylvania, 16.
Eocene:
South Carolina, 86.
Miocene:
Atlantic Coastal Plain, 86.
Louisiana, 210.
South Carolina, 86.
Neocene:
Idaho, 310.
Oligocene:
Louisiana, 210.
Quaternary:
Louisiana, 210.
Mississippi, 266.
Pleistocene.
Great Plains, 214.
Idaho, 310.

Underground waters, relation to oil and gas, 3, 150, 226, 422, 436, 525.

Underground waters, total amount of, 500.

Underground waters, work of:
Action of thermal waters on rocks, 199, 201, 574, 587, 595.
Alteration of rocks by springs, 201, 311, 587, 595.
Cementation, 522, 565.
Decay of rocks due to percolating waters, 478.
Deposits. See Deposits.
Dolomitization, 519.
Enlargement of quartz grains, 263.
Ferration, 519.
Landslides, 75.
Metamorphism, 565.
Oxidation, 522.
Petrifaction, 480.
Silicification, 519.
Solution. See Solution.
Weathering, 522, 565.
Work of thermal waters, general, 145.

Underground waters, circulation of. See Circulation.

Underground waters, deposits of. See Deposits, groundwaters.

Underground waters, descriptions. See under States.

Underground waters, fluctuations of level. See Fluctuations.

Underground waters, part of, in formation of ore deposits. See Ore deposits.

Underground waters as a source of public supplies. See Public supplies.

Underground waters, uses of. See Uses of underground waters.

United States.
Principal Survey publications on underground waters:
Hydrography, report of, progress of, division of, 1893–4, 345.
Hydrography, report of, progress of, division of, 1895, 347.
Hydrology, division of, organization and work of eastern section, 167.
Hydrology, work of division of, 471.
Hydrology of eastern United States, contributions to, 1903, 166.
Hydrology, western, 104.
Irrigation survey, first annual report of, 435.
Irrigation survey, second annual report of, 437.
Lists and analyses of mineral springs, 392.
Mineral waters, 390, 391, 393, 394, 398, 402, 403, 404, 405, 406, 407, 409, 411, 412, 413, 414, 415, 416, 417.
Notes on wells, springs, and general water resources of certain Eastern States, 168.
Potable waters of eastern United States, 334
Preliminary list of deep borings, 95, 96.
Public lands and their water supply, 346.
Reclamation Service, first annual report, 374.
River station, operations at, 1899, 253, 254, 255.
River station, operations at, 1900, 256, 257, 259.
River stations, operations at, 1901, 260.
Salt-making processes, 51.
Stream measurements, 1896, 105.
Stream measurements, 1897, 354.
Stream measurements, 1898, 357.
Stream measurements, 1899, 362.
Stream measurements, 1900, 364.
Stream measurements, 1901, 369.
Stream measurements, 1902, 370, 371, 372, 373.

Upper Helderberg limestone, 379.

Uses of underground waters:
Springs:
Bathing:
California, 148.
Idaho, 317.
Montana, 317, 594.
Porto Rico, 317, 594.
General, 426, 487.
Heating, 487.
Irrigation:
California, 477.
Idaho, 310, 374.
Texas, 357, 536, 537, 569.
General, 387, 622.

Uses of underground waters—Continued.
Springs—Continued.
Medicinal (therapeutic), 58, 426.
Power:
Texas, 215, 537.
General, 357.
Resorts:
Montana, 586, 594.
United States, 392, 406.
Public supplies:
Georgia, 327.
Ohio, 152.
Vermont, 420.
General:
Alabama, 392.
Alaska, 392.
Arizona, 392.
Arkansas, 392, 446.
California, 392.
Colorado, 392.
Connecticut, 183, 392.
Dakotas, 392.
Delaware, 392.
Georgia, 327, 392.
Florida, 169, 392.
Idaho, 392.
Illinois, 392.
Indiana, 392.
Indian Territory, 392.
Iowa, 392.
Kansas, 392.
Kentucky, 392.
Louisiana, 392.
Maine, 18, 392.
Maryland, 392.
Massachusetts, 73, 392.
Michigan, 71, 392.
Minnesota, 207, 392.
Mississippi, 392.
Missouri, 497.
Montana, 392.
Nebraska, 392.
Nevada, 392.
New Hampshire, 27.
New Jersey, 392.
New Mexico, 392.
New York, 392, 610.
North Carolina, 392.
Ohio, 392.
Oregon, 392.
Pennsylvania, 392.
Rhode Island, 74, 392.
South Carolina, 392.
Tennessee, 392.
Texas, 392.
United States, 406.
Utah, 392.
Vermont, 392, 420.
Virginia, 392.
Washington, 392.
West Virginia, 392.
Wisconsin, 392.
Wyoming, 392.
Yellowstone National Park, 392.
Wells:
Bathing, 487.
Heating, 487.
Uses of underground waters—Continued.
Irrigation:
Algiers, 337.
Arizona, 107, 282.
California, 49, 187, 208, 321.
Dakotas, 84.
Georgia, 362.
Great Plains, 72.
Idaho, 488.
India, 550, 624.
Kansas, 212.
Louisiana, 165.
Molokai, 314.
Nebraska, 90, 91.
Public lands, 346.
South Dakota, 89.
Texas, 252, 536.
United States, 343.
Washington, 505.
General, 45, 356, 374, 437, 487, 527, 622.
Lake supplies, South Dakota, 89.
Power:
Dakotas, 84.
Tennessee, 442.
Water supplies, Ohio and Indiana, 301.
General:
Alabama, 502.
Connecticut, 188.
Florida, 169.
Kentucky, 177.
Maine, 18.
Massachusetts, 73.
Michigan, 71, 279.
Minnesota, 207.
Missouri, 497.
New Hampshire, 29.
New York, 610.
Pennsylvania, 467.
Rhode Island, 74.
Tennessee, 176.
General, 364.
Utah.
Cave deposits, 146.
Mine waters:
Descriptions, 26, 27, 28, 549.
Use for water supplies, 26, 27.
Mineral waters, production of. See Mineral waters.
Ore deposits, part of underground waters in formation of, 143, 298, 518, 520, 549, 575.
Principal Survey publication:
Seepage waters in northern Utah, 155.
Seepage, 155.
Solfataras, 110.
Springs, common and thermal:
Analyses, 53, 56, 392.
Descriptions, 27, 170, 392, 504, 534, 549
Occurrence on faults, 170.
Quality, 392.
Source of sulphur, 110.
Temperature, 392.
Uses, 392, 406.
Yield, 392, 406.
Underground waters:
Descriptions, 504.
Level of, 146.
Water horizons, 549.

Vermont.
Mine waters, 598.
Mineral waters, production of. See Mineral waters.
Principal Survey publication:
Town water supplies, analyses and well and spring records, 420.
Springs:
Analyses, 392, 420.
Descriptions, 392, 420.
Quality, 392, 420.
Source, 420.
Temperature, 392, 420.
Uses, 392, 406, 420.
Yield, 392, 420.
Underground waters:
Analyses of public supplies, 420.
Occurrence, 420.
Use for public supplies, 420.
Wells:
Analyses, 420.
Descriptions, 420.
Quality, 420.
Records, 420.
Source, 420.
Yield, 420.
Work of U. S. Geological Survey, 167, 580.
Vesicles, waters in, 565.
Virginia.
Brines, analyses of, 131.
Descriptions, 619.
Mineral waters, production of. See Mineral waters.
Principal Survey publications:
Artesian well prospects in the Atlantic Coastal Plain, 86.
Nomini folio, 87.
Norfolk folio, 79.
Washington folio, 94.
Sinks and caves, 92.
Springs:
Analyses, 53, 54, 56, 392.
Descriptions, 86, 92, 154, 354, 392, 442.
Quality, 392.
Temperature, 392.
Thermal, 92.
Uses, 392, 406.
Yield, 392, 406.
Underground waters:
Descriptions, 78, 87, 94, 97, 385.
Work of, 92.
Water horizons, 78, 86, 87, 94, 97.
Wells:
Analyses, 97.
Descriptions, 86.
Prospects, 86.
Records, 86, 97, 154, 468, 479, 613.
Temperature, 86, 96.
Work of U. S. Geological Survey, 439, 574, 576.
Washington.
Infiltration works, 481.
Mineral waters, production of. See Mineral waters.
Principal Survey publications:
Ellensburg folio, 506.
Geology and water resources of Yakima County, 505.
Washington—Continued.
Principal Survey publications—Continued.
Geological reconnaissance in central Washington, 480.
Reconnaissance in southeastern Washington, 481.
Springs:
Analyses, 392, 426.
Descriptions, 260, 354, 392, 425, 426, 505, 506, 507.
Occurrence on fissures and faults, 480.
Quality, 392.
Temperature, 392.
Use:
Medicinal and bathing purposes, 426.
Resorts, 406.
General, 392.
Yield, 392, 406.
Underground-stream channels, 377.
Underground waters:
Circulation, 505.
Descriptions, 374, 441, 480, 481, 505, 506, 507.
Movements, 505.
Occurrence in lava, 480, 481.
Petrifaction by, 480.
Principles of occurrence, 480, 481.
Work of solution, 377.
Water horizons, 480, 481.
Wells:
Construction, 506.
Descriptions, 369, 354, 506.
Discharge, 369.
Location of, 480.
Records, 480.
Temperature, 96, 480, 505.
Use for irrigation, 505.
Work of U. S. Geological Survey, 25, 43, 578, 580.
Water, artesian and underground. See Underground waters.
Water supplies, public. See Public supplies.
Water table, general discussion of, 500.
Waverly formation, waters of, 380.
Weathering by underground waters, 522, 565.
Wells and borings.
Construction:
Arrangement, 45, 480.
Drilling and casing:
California, 259.
Colorado, 245.
Dakotas, 84.
High Plains, 268.
Louisiana, 210.
Michigan, 141.
South Dakota, 540.
Washington, 505.
General, 45, 354, 485, 488.
Testing, 45, 277, 480, 484, 485, 486, 488, 500.
Contamination of, 494, 500.
Cost of. See Cost of wells.
Deposits in, incrustation, 55.
Descriptions. See under States.
Interference of, 407, 499, 500, 540.
Mineral. See Mineral water.
Pumping. See Pumping.
Records. See Records.
Relation to faults. See Faults.

Wells and borings—Continued.
Statistics. See Records, and Wells under States.
Yield. See Discharge.
Western Gulf coast:
Association of underground waters with oil, etc., 3.
Salt springs, 3.
Sulphur waters, 3.
Well records, 3.
Western interior, well records, 2.
West Virginia.
Brines, 108, 449, 616.
Mineral waters, production of. See Mineral waters.
Sinks and caverns, 89, 92.
Springs:
Analyses, 392.
Descriptions, 392.
Quality, 392.
Temperature, 392.
Uses, 392, 406.
Yield, 392, 406.
Thermal springs, 92.
Underground waters, solution by, 88, 92.
Wells:
Records, 38, 39, 40, 468.
Temperature, 68, 171, 172, 439, 440, 574.
Work of U. S. Geological Survey on well temperatures, 574.
Wisconsin.
Mineral waters, production of. See Mineral waters.
Ore deposits, part of underground waters in, formation of, 563.
Springs:
Analyses, 392.
Descriptions, 392.
Quality, 392.
Temperature, 392.
Uses, 392, 406.
Yield, 392, 406.
Wells of the driftless area, 46.
Wells, temperature, 96.
Work of U. S. Geological Survey, 167, 471, 580.
Wissahickon gneiss, waters of, 16.
Woodbine formation, waters of, 242.
Work on underground waters. See Hydrologic work.
Wyoming. See also Yellowstone National Park.
Brines, 4, 102.
Mine waters, 517.
Mineral waters, production of. See Mineral waters.
Ore deposits, part of underground waters, in formation of, 517.
Principal Survey publications.
Analyses of waters of Yellowstone National Park, 178.
Newcastle folio, 102.
Water resources of the Black Hills and Wyoming, 93.
Water resources of the Patrick and Goshen Hole quadrangles, 4.
Yellowstone National Park folio, 199.
Seepage, 4.
Wyoming—Continued.
Springs:
Analyses, 392.
Deposits, 136, 201.
Descriptions, 4, 57, 58, 98, 392.
Lists, 191.
Quality, 392.
Solution by, 151.
Sulphur, 136, 151.
Temperature, 392.
Use, 392.
Yield, 392.
Thermal springs:
Deposits, exhibit of, at Chicago World's Fair, 198.
Descriptions, 136, 151, 201.
Relation to anticline, 136.
Sulphur, 201.
Work of U. S. Geological Survey on, 192, 193, 194, 195, 196.
Underground waters:
Action on rock, 201.
Circulation, 517.
Occurrence in Black Hills, 93.
Prospects, 512.
Work of solution, 151.
Water horizons, 4, 93, 102.
Wells:
Analyses, 102.
Records, 93, 102.
Work of U. S. Geological Survey, 104, 192, 193, 194, 195, 577, 578, 580.
Yellowstone National Park.
Geysers:
Action—
Antiquity of, 199.
Changes in, 434.
Work on, 190, 191.
Analyses, 54.
Deposits—
Antiquity of, 199.
Descriptions, 192, 193, 194, 199.
Exhibit at Chicago World's Fair, 198.
Descriptions, 192, 193, 194, 195.
Work on, 57, 190, 192, 193, 194, 195, 196.
Principal Survey publications:
Analyses of waters of Yellowstone National Park, 178.
Yellowstone National Park folio, 199.
Springs, common and thermal:
Action, 195.
Action on rocks, 199, 587.
Algous growth in, 193, 587.
Analyses, 54, 58, 178, 191, 393.
Analyses, list of, 191.
Composition, 57, 178, 192, 194, 392, 434, 583.
Deposits—
Analyses, 65.
Antiquity of, 199.
Descriptions, 192, 193, 194, 196, 584, 587.
Temperature, 178, 190, 390.
Therapeutic value, 58.
Use, 392.
Work on, 57, 189, 196, 432, 433, 434.
Yield, 392.
Work of U. S. Geological Survey, 57, 189, 190, 432, 433, 434.
Yield of springs and wells. See Discharge.

O

PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Water-Supply Paper No. 120.]

The serial publications of the United States Geological Survey consist of (1) Annual Reports, (2) monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of United States—folios and separate sheets thereof, (8) Geologic Atlas of the United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

The Professional Papers, Bulletins, and Water-Supply Papers treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous; H, Forestry; I, Irrigation; J, Water storage; K, Pumping water; L, Quality of water; M, General hydrographic investigations; N, Water power; O, Underground water; P, Hydrographic progress reports. This paper is the thirty-fourth in Series O, the complete list of which follows. (PP=Professional Paper; B=Bulletin; WS=Water-Supply Paper.)

SERIES O—UNDERGROUND WATERS.

WS 4. A reconnaissance in southeastern Washington, by I. C. Russell. 1897. 96 pp., 7 pls.
WS 6. Underground waters of southwestern Kansas, by E. Haworth. 1897. 65 pp., 12 pls.
WS 7. Seepage waters of northern Utah, by Samuel Fortier. 1897. 50 pp., 3 pls.
WS 12. Underground waters of southeastern Nebraska, by N. H. Darton. 1898. 56 pp., 21 pls.
WS 21. Wells of northern Indiana, by Frank Leverett. 1899. 82 pp., 2 pls.
WS 26. Wells of southern Indiana (continuation of No. 21), by Frank Leverett. 1899. 64 pp.
WS 30. Water resources of the Lower Peninsula of Michigan, by A. C. Lane. 1899. 97 pp., 7 pls.
WS 31. Lower Michigan mineral waters, by A. C. Lane. 1899. 97 pp., 4 pls.
WS 34. Geology and water resources of a portion of southeastern South Dakota, by J. E. Todd. 1900. 34 pp., 19 pls.
WS 53. Geology and water resources of Nez Perces County, Idaho, Pt. I, by I. C. Russell. 1901. 86 pp., 10 pls.
WS 54. Geology and water resources of Nez Perces County, Idaho, Pt. II, by I. C. Russell. 1901. 87–141 pp.
WS 55. Geology and water resources of a portion of Yakima County, Wash., by G. O. Smith. 1901. 68 pp., 7 pls.
WS 57. Preliminary list of deep borings in the United States, Pt. I, by N. H. Darton. 1902. 60 pp.
WS 59. Development and application of water in southern California, Pt. I, by J. B. Lippincott. 1902. 95 pp., 11 pls.
WS 60. Development and application of water in southern California, Pt. II, by J. B. Lippincott. 1902. 96–140 pp.
WS 61. Preliminary list of deep borings in the United States, Pt. II, by N. H. Darton. 1902. 67 pp.
WS 67. The motions of underground waters, by C. S. Slichter. 1902. 106 pp., 8 pls.
B 199. Geology and water resources of the Snake River Plains of Idaho, by I. C. Russell. 1902. 192 pp., 25 pls.
WS 77. Water resources of Molokai, Hawaiian Islands, by W. Lindgren. 1903. 62 pp., 4 pls.
WS 78. Preliminary report on artesian basin in southwestern Idaho and southeastern Oregon, by I. C. Russell. 1903. 53 pp., 2 pls.
PP 17. Preliminary report on the geology and water resources of Nebraska west of the one hundred and third meridian, by N. H. Darton. 1903. 69 pp., 43 pls.
WS 90. Geology and water resources of part of the lower James River Valley, South Dakota, by J. E. Todd and C. M. Hall. 1904. 47 pp., 28 pls.

WS 101. Underground waters of southern Louisiana, by G. D. Harris, with discussions of their uses for water supplies and for rice irrigation, by M. L. Fuller. 1904. 98 pp., 11 pls.
WS 102. Contributions to the hydrology of eastern United States, 1903, by M. L. Fuller. 1904. 522 pp.
WS 104. Underground waters of the Gila Valley, Arizona, by W. T. Lee. 1904. 68 pp., 5 pls.
WS 106. Water resources of the Philadelphia district, by Florence Bascom. 1904. 75 pp. 4 pls.
WS 110. Contributions to the hydrology of eastern United States, 1904; M. L. Fuller, geologist in charge. 1905. 211 pp., 5 pls.
PP 32. Geology and underground water resources of the central Great Plains, by N. H. Darton. 1905. 433 pp., 72 pls.
WS 111. Preliminary report on underground waters of Washington, by Henry Landes. 1905. 85 pp., 1 pl.
WS 112. Underflow tests in the drainage basin of Los Angeles River, by Homer Hamlin. 1905. 55 pp., 7 pls.
WS 114. Underground waters of eastern United States, by M. L. Fuller and others. 1905. 285 pp., 18 pls.
WS 118. Geology and water resources of east-central Washington, by F. C. Calkins. 1905. 96 pp., 4 pls.
B 252. Preliminary report on the geology and water resources of central Oregon, by I. C. Russell. 1905. 138 pp., 24 pls.
WS 120. Bibliographic review and index of papers relating to underground waters published by the United States Geological Survey, 1879–1904, by M. L. Fuller. 1905. 128 pp.

The following papers also relate to this subject: Underground waters of Arkansas Valley in eastern Colorado, by G. K. Gilbert, in Seventeenth Annual, Pt. II; Preliminary report on artesian waters of a portion of the Dakotas, by N. H. Darton, in Seventeenth Annual, Pt. II; Water resources of Illinois, by Frank Leverett, in Seventeenth Annual, Pt. II; Water resources of Indiana and Ohio, by Frank Leverett, in Eighteenth Annual, Pt. IV; New developments in well boring and irrigation in eastern South Dakota, by N. H. Darton, in Eighteenth Annual, Pt. IV; Rock waters of Ohio, by Edward Orton, in Nineteenth Annual, Pt. IV; Artesian well prospects in the Atlantic Coastal Plain region, by N. H. Darton, Bulletin No. 138.

Correspondence should be addressed to

THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, D. C.

APRIL, 1905.

LIBRARY CATALOGUE SLIPS.

[Mount each slip upon a separate card, placing the subject at the top of the second slip. The name of the series should not be repeated on the series card, but the additional numbers should be added, as received, to the first entry.]

Author.

Fuller, Myron L[eslie] 1873–

. . . Bibliographic review and index of papers relating to underground waters published by the United States Geological survey, 1879–1904, by Myron L. Fuller. Washington, Gov't print. off., 1905.

128, iii p. 23cm. (U. S. Geological survey. Water-supply and irrigation paper no. 120)

Subject series: O, Underground waters, 34.

1. Water, Underground—Bibl. 2. Water, Underground—U. S.

Subject.

Fuller, Myron L[eslie] 1873–

. . . Bibliographic review and index of papers relating to underground waters published by the United States Geological survey, 1879–1904, by Myron L. Fuller. Washington, Gov't print. off., 1905.

128, iii p. 23cm. (U. S. Geological survey. Water-supply and irrigation paper no. 120)

Subject series: O, Underground waters, 34.

1. Water, Underground—Bibl. 2. Water, Underground—U. S.

Series.

U. S. Geological survey.

Water-supply and irrigation papers.

no. 120. Fuller, M. L. Bibliographic review and index of papers relating to underground waters published by the U. S. Geological survey. 1905.

References.

U. S. Dept. of the Interior.

see also

U. S. Geological survey.

Water-Supply and Irrigation Paper No. 121 Series L, Quality of Water, 9

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

PRELIMINARY REPORT

ON THE

POLLUTION OF LAKE CHAMPLAIN

BY

MARSHALL ORA LEIGHTON

WASHINGTON
GOVERNMENT PRINTING OFFICE
1905

CONTENTS.

	Page.
Letter of transmittal	7
Introduction	9
Lake Champlain	11
History and development	11
General description	14
Characteristics of water	20
Bouquet River	21
Origin, course, and flow	21
Soda-pulp pollution	23
Constituents of the pulp	23
Manufacture of the pulp	24
Water used	25
Supplies and wastes	25
First liquid effluent	25
Recovery of soda	28
Second, third, and fourth liquid effluents	29
Causticizing process	30
Production of bleach	32
Disposal of sludge	33
Sedimentation bed	33
Wastes	33
Waste No. 1	33
Waste No. 3	34
Waste No. 4	34
Efficiency of sedimentation bed	35
Sedimentation-bed effluent	36
Effects of soda-pulp waste	36
Effect on Bouquet River	36
Character and extent	36
Conclusions	38
Effect on Lake Champlain	39
Methods of investigation	39
Sample series of August 12	41
Sample series of August 21	43
Sample series of August 31	45
Conclusions	47
Ausable River	48
Origin and course	48
Sulphite-pulp pollution	49
Manufacture of the pulp	49
Methods	49
Wastes	50
Effect of sulphite-pulp wastes	51
Effect on Ausable River	51

Page.

Ausable River—Continued.
Sulphite-pulp pollution—Continued.
Effect of sulphite-pulp wastes—Continued.
Effect on Lake Champlain 53
Methods of investigation 54
Sample series of August 23 54
Sample series of September 2 56
Sample series of September 17 61
Conclusions 62
Burlington and Winooski River 66
Sewage pollution 66
Sources of sewage and places of discharge 66
Effect on Lake Champlain 67
Earlier investigations 68
Present conditions 74
Sample series of September 16 75
Sample series of September 17 77
Sample series of September 22, No. 1 78
Sample series of September 22, Nos. 2 and 3 83
Sample series of September 25 85
Conclusions 88
Upper end of Lake Champlain 90
Soda-mill and sewage pollution 90
Character of upper-lake water 91
Character of Ticonderoga Creek water above pulp mill 93
Ticonderoga Pulp and Paper Company 94
Manufacture of the pulp 95
Sedimentation bed 96
Effect of mill wastes 97
Effect on Ticonderoga Creek 97
Comparison of creek waters above and below mill 98
Comparison of creek and lake waters 99
Effect on Lake Champlain 102
Sample series of August 27 102
Sample series of September 9 102
Conclusions 107
General conditions in Lake Champlain 108
Algæ 108
General conditions of existence 109
Algæ in Lake Champlain 110
Effect of mill waste on algæ 110
Experiment 1 110
Experiment 2 110
Bacteria 111
Effect of mill wastes on bacteria 111
Samples for testing 111
Report of Mr. Earl B. Phelps 111
Determinations 111
Effect of wastes on mosquitoes 111
Germicidal effect of wastes on sewage bacteria 112
Effect of wastes on specific disease germs 113
Conclusions 114
Fish 114
Sawdust and ground wood 115
Summary 115
Index 117

ILLUSTRATIONS.

		Page.
PLATE I.	Map of Lake Champlain and vicinity	14
II.	*A*, Ruins of Crown Point Fortress; *B*, Waste trough crossing Bouquet River at Willsboro mill	18
III.	*A*, Bouquet River above Willsboro; *B*, Falls in Bouquet River at Willsboro	22
IV.	*A*, Soda-pulp mill at Willsboro; *B*, Ausable Chasm	24
V.	*A*, Effluent weir from Willsboro sedimentation bed; *B*, Falls at head of Ausable Chasm	32
VI.	Bouquet sample series of August 12, 1904	40
VII.	Bouquet sample series of August 21, 1904	42
VIII.	Bouquet sample series of August 31, 1904	46
IX.	*A*, Wood pulp and sawdust on west shore of Lake Champlain; *B*, Falls on Ausable River at Keeseville, N. Y	48
X.	*A*, Burlington, Vt., lake front; *B*, Trunk sewer outlet, Burlington, Vt.	66
XI.	*A*, Water power of Ticonderoga Pulp and Paper Company, Ticonderoga, N. Y.; *B*, View at Ticonderoga, N. Y	90
XII.	Water power of International Pulp Company, Ticonderoga Creek: *A*, "A" mill; *B*, "B" mill	92
XIII.	*A*, Sedimentation bed of Ticonderoga Pulp and Paper Company; *B*, Mills of Ticonderoga Pulp and Paper Company	96
FIG. 1.	Ausable sample series of August 23, 1904	54
2.	Ausable sample series of September 2, 1904	57
3.	Ausable sample series of September 17, 1904	60
4.	Burlington sample series of September 16 and 17, 1904	77
5.	Burlington sample series of September 22, 1904, No. 1	79
6.	Burlington sample series of September 22, 1904, Nos. 2 and 3	84
7.	Burlington and Winooski sample series of September 25, 1904	87
8.	Ticonderoga sample series of August 27, 1904	101
9.	Ticonderoga sample series of September 9, 1904	105

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
HYDROGRAPHIC BRANCH,
Washington, D. C., December 12, 1904.

SIR: I have the honor to transmit herewith a manuscript entitled "Preliminary Report on the Pollution of Lake Champlain," by Marshall Ora Leighton, and to request that it be published as one of the series of Water-Supply and Irrigation Papers.

Lake Champlain is an interstate and international body of water. In colonial times it was of great commercial importance, and with the development of the national resources in its immediate drainage area it became a great highway. Its greatest industrial importance was during the period 1860 to 1890, since which time, by reason of railroad competition and the closing of many industries, its commercial position has steadily declined. At present it appears that its future usefulness will be that of a source of water supply, and therefore the character of the lake water is of first importance.

The investigations reported in this paper were made in response to a request of Hon. John G. McCullough, governor of the State of Vermont. A remarkably persistent agitation had been going on concerning the pollution of the lake by certain cities and industrial plants, and allegations were made which involved the States of New York and Vermont, with all the consequent interstate and international questions. The time at the disposal of the author was too short to complete an extended investigation of the whole question, and therefore the work was confined to a consideration of the specific points at issue. The investigations reported are of great value outside of the immediate area tributary to Lake Champlain, for the subject of pollution of natural waters by industrial wastes is of prime importance in every manufacturing region.

Very respectfully,

F. H. NEWELL,
Chief Engineer.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

PRELIMINARY REPORT ON THE POLLUTION OF LAKE CHAMPLAIN.

By M. O. LEIGHTON.

INTRODUCTION.

Certain persons owning property along the shores of Lake Champlain allege that the water of the lake is being polluted by enormous discharges of waste materials from the several wood-pulp mills located upon the tributary streams in New York State. They also claim that sewage from the various cities situated on the lake border, especially from Burlington, Vt., is a damage to the water, though to a far less degree than that from the pulp mills. The allegations of these parties to the controversy may be briefly summed up as follows:

1. That the water of the lake has been rendered unfit for domestic consumption.

2. That the discharges from the mills are destructive to fish life and that dead fish are washed upon the shores in ruinous quantities.

3. That the taste of the water is so disagreeable that cattle refuse to drink it and the usefulness of the lake as a watering place for stock is thereby destroyed.

4. That the wastes from the mills promote a luxuriant growth of green algæ, which, gathering along the shores, make them unattractive and decrease the value of property for summer homes.

5. That the proprietors of the pulp mills wantonly discharge these wastes into the lake, making no worthy efforts to improve the condition, but rather postponing by equivocation, false promises, and legal subterfuges the day of rightful adjustment.

In response to these allegations the proprietors of the various mills state that the wastes discharged into the lake are in nowise harmful thereto, that they are taking all possible precautions against and have spent large sums of money to prevent the pollution of the lake, and that the parties to the complaint are misinformed, unduly alarmed, or wantonly untruthful.

The city of Burlington, Vt., the largest community upon the lake, draws its water supply therefrom and discharges its sewage at a point less than 3 miles from the water intake. In this city there appears to be little apprehension concerning the influence of the city sewage upon

the water supply, but great alarm has been felt lest the wastes from the pulp mills on the New York side of the lake should flow across the normal lake current for 10 miles and poison the city supply.

The conditions outlined above led at first to a mild and considerate discussion among the parties interested, which finally developed into an acrimonious struggle, full of personal bitterness and involving in the end both the New York and the Vermont State governments. Through the press the conditions were widely advertised and much distorted. The situation became so acute that a thorough investigation was deemed necessary, and the following communication was addressed to the Director of the United States Geological Survey by the Hon. John G. McCullough, Governor of the State of Vermont:

NORTH BENNINGTON, VT., *March 31, 1904.*

SIR: An extended examination of the waters of Lake Champlain with especial reference to the effect of polluting materials turned into the lake would be extremely desirable and of public benefit at the present time.

Lake Champlain is, as you are aware, an interstate body of water and its resources are of great importance to the States of Vermont and New York. In order that these resources may be conserved it is necessary that the purity of its waters be maintained. Therefore a determination of the present condition of the lake, the effect of the wastes which are being poured into it, and the conditions which are likely to arise in the future if present practices with reference to waste disposal are continued is highly desirable.

On account of the interstate features which prevail, I am of the opinion that the work above outlined can better be carried on by some national authority, and as I am informed that the hydrographic branch of the United States Geological Survey is empowered by Congress to determine the water supplies of the United States and an appropriation is made therefor, I respectfully request that an equitable portion of the funds available for such work be applied to the investigation of Lake Champlain and that properly qualified officials be assigned to the work.

Respectfully, yours,

JOHN G. MCCULLOUGH, *Governor.*

The DIRECTOR
U. S. Geological Survey, Washington, D. C.

In compliance with the above request the author of this report was detailed to carry on the investigations, and entered upon the work July 1, 1903. He desires here to make acknowledgment of timely services rendered during the investigation by many persons, and especially by Mr. Edward Hatch, jr., and Mr. A. H. Ellis, the principal parties to the original complaints; Mr. A. G. Paine, jr., general manager of the New York and Pennsylvania Company; Mr. R. L. P. Mason, superintendent of the Champlain Mills of the New York and Pennsylvania Company; Mr. Charles E. Bush, general manager of the Ticonderoga Pulp and Paper Company; Mr. James Rogers, of the J. and J. Rogers Company; Dr. B. H. Stone and Mr. C. P. Moat, of the State laboratory of hygiene, Burlington, Vt.; Hon. Edward L. Bates, secretary of civil and military affairs, State of Vermont; and, finally, to His Excellency, Governor John G. McCullough, State of Vermont.

LAKE CHAMPLAIN.

HISTORY AND DEVELOPMENT.

Samuel de Champlain, a native of Brouage, a Catholic supporter of Henry of Navarre, sometime in the service of Spain in the Caribbean, and finally a governor of New France, discovered Lake Champlain on July 4, 1609. The purposes of his journey from the new settlement at Quebec to this body of water were not those of exploration and discovery, nor was he actuated by the spirit of legitimate conquest as it was then recognized. His first visit to the lake was in confirmation of an agreement with the Algonquian Nation to intervene in the struggle between it and the Iroquois. The discovery of Lake Champlain was but an incident in an ill-advised campaign which in after years brought untold suffering and death to French colonists—a campaign which has never been justified, rarely defended, and which in the final analysis seems to have been merely the indiscreet act of a brave and distinguished warrior impatient of his idle sword.

The discovery of Lake Champlain and the discoverer's espousal of the Algonquian cause is all important in the subsequent history of the lake. The country thereabout became a battle ground on which was fought out the relentless hatred of the Iroquois for the French. "It was but a holiday skirmish for the French, but it was the cause of a bitter and bloody hatred on the part of the Iroquois, a hatred which afterwards never slept. The long-standing enmity cherished by that nation toward the Algonquins extended thenceforth to the French also. In later years, when the English and Dutch sided with the Iroquois, the feud became a fierce and deadly war that at times threatened the life of the whole colony of New France."[a]

So it was that Lake Champlain afterwards became a route by which the northern and southern Indian nations made their attacks upon each other. It was hotly contested country during all the colonial wars between the French and the English, and after the British dominion included Canada it was again a great warpath during the war of the Revolution and that of 1812. During all these years the country grew in commercial and political importance, and the lake was a great highway in times of peace. With the opening of Champlain Canal, connecting the southern end of the lake with Hudson River, there came days of prosperity. Iron mines were opened in the Adirondack Mountains, the products of which found a ready outlet by way of the lake. The lumber interests were enormous, and many small ports grew up as centers for these products. The lake was a busy and bustling place, dotted over with lines of canal boats, rafts of logs, and vessels under sail and steam.

[a] Dix, Edwin Asa, Champlain, the founder of New France, p. 114.

All this has now practically disappeared. The visitor to the lake to-day will see at rare intervals a solitary line of canal boats under convoy of a steam towboat, a passenger steamer, of which there are several, making landings at important points, or the private boat of some well-to-do sojourner; oftener he will see nothing but a large expanse of water backed by blue mountains and intercepted here and there by groups of islands. This diminution of freight traffic seems to the observer even greater than the actual figures (Table II, p. 13) prove it to be. The freight is largely carried in canal boats, which are drawn together in a double line consisting usually of 30 to 40 individual boats. Thus a heavy tonnage is carried without giving to the lake the animated appearance which would result if the same burden were carried by many smaller boats. Viewed from many directions the lake is almost as solitary now as it must have been on the day of its discovery. It is a deep, long, narrow sea, beautiful in its details, whimsical in its changes, and treacherous in its storms. The cities and towns upon its banks have in many cases maintained their prosperity, though not by virtue of their position with reference to the lake. Many others have lapsed into rural distributing centers, interesting only in their memories.

The following table shows clearly the rise and fall of communities in the Lake Champlain region:

TABLE I.—*Population of towns bordering on Lake Champlain.*

	1820.	1830.	1840.	1850.	1860.	1870.	1880.	1890.	1900.
Champlain, N. Y	1,618	2,456	3,632	5,067	5,857	5,080	5,407	5,207	4,748
Chazy, N. Y	2,313	3,097	3,584	4,324	3,399	3,206	3,147	2,867	2,796
Plattsburg, N. Y	3,519	4,918	6,416	5,618	6,670	8,414	8,283	9,500	11,612
Chesterfield, N. Y. (including Keeseville)	667	1,671	2,716	4,171	3,179	2,795	2,752	2,548	2,382
Willsboro, N. Y	888	1,316	1,658	1,932	1,519	1,719	1,450	1,568	1,522
Essex, N. Y	1,225	1,543	1,681	2,351	1,633	1,600	1,462	1,437	1,333
Westport, N. Y	1,095	1,513	1,932	2,352	1,981	1,577	1,737	1,864	1,727
Moriah, N. Y	842	1,742	2,595	3,065	3,466	4,683	7,379	6,787	4,447
Crown Point, N. Y	1,522	2,041	2,212	2,378	2,252	2,449	4,287	3,135	2,112
Ticonderoga, N. Y	1,493	1,996	2,169	2,590	2,271	2,669	3,304	3,980	5,048
Whitehall, N. Y	2,341	2,888	3,813	4,726	4,862	5,564	5,347	5,402	5,295
West Haven, Vt	.....	724	774	718	580	713	492	412	375
Benson, Vt	.....	1,493	1,403	1,305	1,256	1,244	1,104	880	844
Orwell, Vt	.....	1,598	1,504	1,470	1,341	1,192	1,351	1,265	1,150
Vergennes, Vt	.....	999	1,017	1,578	1,286	1,570	1,782	1,773	1,758
Burlington, Vt	.....	3,526	4,271	7,521	7,713	14,387	11,365	14,590	18,640
St. Albans, Vt	.....	2,395	2,702	1,814	3,637	7,014	7,193	7,771	7,954

TABLE II.—*Freight traffic on Lake Champlain since 1833.*

[Tons.]

Year.	Entered.	Cleared.	Year.	Entered.	Cleared.
1833	67,477	67,101	1870	337,040	336,565
1837	50,011	50,011	1871	325,668	318,675
1838	62,008	62,008	1872	327,529	329,182
1840	109,516	109,516	1873	350,202	354,937
1843	52,453	52,274	1874	273,619	274,962
1844	107,386	108,182	1875	212,133	204,800
1845	89,801	89,073	1876	192,856	192,629
1846	104,571	108,212	1878	174,875	169,665
1848	175,522	170,196	1879	179,324	186,227
1849	193,988	192,536	1880	203,103	203,856
1850	207,392	190,813	1881	213,407	219,506
1851	217,855	212,648	1882	248,508	249,939
1852	78,353	80,117	1883	249,949	156,424
1853	52,399	52,904	1884	223,260	212,429
1854	102,469	97,678	1885	180,504	172,691
1855	43,441	44,671	1886	178,493	175,782
1856	99,226	94,161	1887	182,326	177,754
1857	122,543	117,336	1888	214,063	222,244
1858	128,355	118,226	1889	209,459	215,790
1859	101,614	96,845	1890	208,185	194,862
1860	69,822	60,614	1891	150,366	157,350
1861	94,132	67,203	1892	137,850	132,626
1862	68,426	56,311	1893	151,189	145,324
1863	103,886	147,652	1894	144,849	149,731
1864	165,330	155,474	1895	163,238	156,840
1865	175,813	172,471	1896	201,070	224,033
1866	187,050	179,365	1897	182,054	181,499
1867	200,623	188,404	1898	179,714	180,710
1868	219,530	201,357	1899	113,130	111,446
1869	294,767	278,431	1900	146,613	156,393

Lake Champlain has become comparatively unimportant from a purely commercial standpoint. Whether or not the improvements contemplated by the State of New York, which will result in increasing the size and capacity of Champlain Canal, will restore the lake to anything like its former importance, is questionable. At all events it will not so enhance the commercial importance of the lake that its future really great function, that of water supply, will be overshadowed. It is apparent that the highest development will be reached as a place for summer homes and as a source of municipal water supply.

As the growth of the urban population becomes still more important, it will be necessary more and more to conserve all those bodies of water that can be retained in practically pure condition and to safeguard them for all future time. Therefore the matter of pollution dealt with in the following pages becomes a most important consideration in connection with the lake and its future.

GENERAL DESCRIPTION OF THE LAKE.

Lake Champlain is a long, narrow basin lying between the States of New York and Vermont and extending across into the Dominion of Canada. Its extreme length is said to be about 130 miles, while its greatest breadth, a short distance north of Ausable Point, is about 11 miles. The lake occupies the narrow valley dividing the Adirondack Mountains of New York from the Green Mountains of Vermont. These mountains come down close to the border of the lake for considerable distances along the New York shore, while on the Vermont side there is generally a good space of rolling country between the shore and the foothills.

The late Prof. Ebenezer Emmons, at one time in charge of investigations in the second geological district of New York (comprising the counties of Warren, Essex, Clinton, Franklin, St. Lawrence, Jefferson, and Hamilton), made a report under date of January 1, 1842, to Governor William H. Seward, in which the following observations were made with reference to Champlain Valley:

> The length of this valley is 180 miles, if it is to be considered as extending to St. Johns; but it appears to open into the valley or basin of the St. Lawrence 20 miles to the south. The greatest depression of this valley is between Westport, Burlington, and Port Kent. By sounding close to the edge of the perpendicular rocks, about 4 miles north of Westport, I found the depth to exceed 300 feet. By soundings at other places in this part of the lake its depth has been found to be 600 feet; it extends, therefore, 500 feet at least below the level of the ocean. Situated as the lake is, entirely upon the western side of the valley, its bed must be regarded as a deep chasm principally in the primary rocks; for from the lake shore upon this side the slope is abrupt along the whole portion where the several mountain ranges reach it, except in those portions of it which are bordered by the minor valleys. The character of the slope upon the east side is quite different from the west; that is, it is longer and much more gradual in its descent; it comprehends most of the valley. In a direct line, or a line perpendicular to the course of the lake and the Green Mountain Range, it can not exceed 25 miles, and probably the average width of this valley is about 20 miles. At many places the lake is bordered by steep banks composed of clay and sand, the greatest height of which is about 100 feet. It is not my purpose, in this place, to consider the nature of this formation or its age, but it is proper to remark that it is marine, as at many points it furnishes an abundance of fossils belonging to those species which are now inhabitants of the sea on the Atlantic coast—those, too, which belong to the same latitudes. Thus, I have found the *Mya arenaria*, *Mya truncata*, *Natica clausa*, *Tritonium anglicum*, *Tritonium fornicatum*, *Scalaria groenlandica*, *Saxicava rugosa*, *Tellina groenlandica*, *Balanus miser*, *Pecten islandicus*, *Terebratula psittacea*, *Modiola* ——, and several other shells, amounting in all to about twenty species, all of which, as has been remarked, belong to the pres-

ent Atlantic shore. We may therefore consider the sediment of this valley as quite recent, and, in addition to this, as having undergone but little change since the marine occupants gave place to the lacustrine.

On the New York side there are several small and unimportant valleys which open into the Champlain. The most important are those of Lake George, which has already been spoken of as extending to the plains of Saratoga, the Bouquet, Ausable, and Saranac. The Bouquet is narrow and runs nearly in the direction of the lake for about 8 miles, along the junction of the primary with the transition rocks. The Ausable is much more important, and is geologically interesting for the gorges in the Potsdam sandstone through which the Ausable flows. The river flows near the southeastern side of this valley, and it is not improbable that it would be proper to consider the Ausable and Saranac as but one valley. Considered as one, it extends 20 miles west of the lake, and north till it terminates in the valley of the St. Lawrence. It lies in the angle formed by the great Adirondack on the south, and Lyon and Whiteface on the west and northwest. It extends, therefore, from Keeseville to Champlain, and from Plattsburg to Redford. Geologically, this valley is important and interesting, particularly as it furnishes a better development of the lower transition rocks than any other part of the State. It is only here that we find the series complete. The phenomena, too, of uplifts and fractures are finely displayed, in addition to which, all the elementary principles of geology may be found illustrated in a field quite accessible.

I have only to notice one other feature in the valley of Champlain, viz, the obliquity of its subordinate valleys. Thus, on the west, or New York side, they open to the northeast; on the east, nearly to the northwest; though as it regards the latter, their course coincides more nearly with the direction of the Green Mountain Range. Thus, the valley of Otter Creek coincides very nearly with that of the lake, or with a north and south direction. These facts, it is true, are unimportant in themselves, and they are only noticed for the purpose of showing more clearly the slope and convergences of the valley. It is only by these facts that this structure can be demonstrated.

The question concerning the age of valleys is quite as important as that of the mountain system. In many instances these two inquiries are connected and inseparable from each other, or the determination of one settles that of the other. Though it is difficult to determine the question under consideration with much exactitude, still there are two or three facts which are important: It is a very ancient valley, a fact which is proved (1) by the organic remains of the clays and sands which form the present floor of the valley; (2) by the smooth and polished surface of the rocks which compose the ancient floor upon which the clays and sands of the post-Tertiary (as the formation has been designated) were deposited, for we can not regard them as having been wholly formed by sudden and violent movements of the loose materials upon the surface. The whole phenomena is one of moderate force, combined with one of power, but yet of long continuance.

The ancient floor of this valley is formed by two classes or systems of rocks: (1) The primary, principally gneiss, and (2) the lower transition, or rocks of the Champlain group, as they are denominated in the subsequent pages. The order of events connected with the formation of this valley may be stated thus: First, the primary rocks, which constituted the floor of an ancient ocean of an unknown extent. Upon these were deposited the sandstones, limestones, and shales of the Champlain group. Thus far the series of rocks appear to be whole and perfect, or without breaks, but after the completion of this group the ocean retired and they became the surface rocks. Subsequent to this, an elevating force deranged the horizontality of the masses, fracturing them extensively in the line of the present valley, and raising them above the waters of the ocean. This line of elevation and of fracture runs close upon the western shore, and merely breaks off the western edges of

the transition. In the third place, we find a current or flood of waters to have swept through this valley and to have removed to a great distance the loose materials of the surface, and by their means to have worn down and polished the surface of the rocks which were exposed. Fourth, we find this valley again occupied by an ocean in which deposits were again accumulating, principally aluminous or of clay, but mixed with calcareous matter in the middle portion and siliceous in the upper. This state of things did not exist long, for the marine relics are few and the formation deposited limited and thin, probably not exceeding 100 feet. In its turn this formation was elevated, and became exposed to currents of water bearing along rocks and stones, being in some places entirely swept away; in others, only the sandy portion, or the upper part; in others it remains entire, especially where it was protected by jutting rocks; thus the stiff blue clay of the inferior portion, the yellow and brownish of the middle, and the sand of the upper, all remain undisturbed. It is in the last two that we find the modern shells principally near their junction. The last sweepings of this deluge of waters formed the present bowlder system, and we find the latter always above the former, or post-Tertiary. Such have been the vicissitudes of this beautiful valley. Twice have the waters of the ocean reposed upon its bosom, and twice has it been swept, as it were, with the besom of destruction. For a long period after the deposition of the Champlain group it remained above the watery element, or during the whole period required for the deposition of the New York transition system—the old red, the Carboniferous, the Secondary, and the great Tertiary; after which, for a short period, it was once more under the sway of Neptune, and the monsters of the deep once more took possession, and the iceberg floated upon its waters. But this state was to be transient, for it was already fitted for the abode of man; the waste was to be reclaimed; the time had already come for man to assume the power and erect his temples in the vale. How long the present floor of this valley has existed can not be told with any exactness approaching to a demonstration, but it is manifest that it is comparatively recent, for the materials being soft would ere this have been entirely removed and the beds destroyed had they existed during the epochs of the Eocene Tertiary, especially in those places where they are exposed to abrasion by rains and floods. Even deep furrows are worn annually in the sands and clays, and they are perceptibly diminishing in extent.

The maximum depth of the lake is 399 feet. Examination of the mariner's chart shows that throughout the greater portion of the lake the depth of water is more than 100 feet.

The head of the lake is at its southernmost end. This is a spot somewhat difficult to determine. Examination of Pl. I will show that from the end of Crown Point south to Whitehall the lake grows constantly narrower, merging gradually into a small stream called Wood Creek. The upper end of the lake is generally understood to be at Whitehall, but there is some difference of opinion on this point. The early settlers regarded Bulwagga Bay, west of Crown Point, as the head of the lake, and early maps designate that part lying between old Fort Ticonderoga and Crown Point, "river flowing into Lake Champlain." There is much to support this view. The current northward from Whitehall to Crown Point is readily perceptible, except when a northerly wind reverses its direction upon the surface. This part of the lake, too, is radically different from that north of Crown Point. Its width varies from a few hundred feet to about a mile, and the depth of water averages about 25 feet

in the tortuous midchannel. The banks and bottom are of sedimentary clay, overgrown with weeds, and shoal water extends well out into the stream. The water is exceedingly turbid, and appears not unlike that of the rivers in the Middle West.

Northward from Crown Point the true lake formation is assumed. The banks diverge, the water deepens, and rocky shores take the place of clay banks. The true basin of the lake runs off steeply near the head of Crown Point. From there to the Canada line the water is without marked turbidity, save where certain outcrops of shale or clay or the sediments from tributary streams create small areas of colored water.

Between Whitehall and the mouth of Ticonderoga Creek or Lake George outlet the country on both sides of the lake is rugged. On the Vermont side the hills within a short distance from the shore rise to heights varying from 200 to 850 feet above the lake surface. The highest point is Bald Mountain, in Rutland County, 4 miles north of Whitehall. The line of hills on this side ends abruptly at Mount Independence, a historic fortification 200 feet above the lake and opposite old Fort Ticonderoga.

On the New York side is a much more precipitous line of hills, varying from 900 to 1,800 feet above the lake and terminating at Mount Defiance, the site of another colonial fortification immediately south of Fort Ticonderoga and separated from it by Lake George outlet. This range is the drainage divide between Lake George and Lake Champlain. The outlet runs around the end of Mount Defiance and enters Lake Champlain by way of the rolling country north of Mount Defiance, descending 221 feet in the intervening 3 miles.

Northward from Ticonderoga to Crown Point, a distance of about 14 miles, the lake varies in width from half a mile to a mile, the shortest distance from shore to shore being opposite the old French fort on the end of Crown Point, where only two-fifths of a mile separates it from Chimney Point on the Vermont side. The country on both sides of this portion of the lake is of a generally rolling character, except where—a short distance south of Crown Point village—Sugar Hill, Breeds Hill, and Dibble Mountain rise up from the water's edge. These prominent points are outlying foothills of the ranges farther west, the highest, Dibble Mountain, being 900 feet above the lake surface.

In colonial times the narrow pass between Crown Point and Chimney Point was believed to be of strategic importance. It was first fortified by the French, the site being called Fort Frederick, and after the English occupation an extensive fort was constructed at an expense of $10,000,000. The place, however, was found to be of no strategic importance. No engagement of any consequence took place there, although the fort was taken several times without any defense upon the part of the garrison. The ruins shown in Pl. II, *A*, are remark-

ably well preserved, and the region is one of the most interesting along Lake Champlain. As shown on the map, Pl. I (p. 14), Bulwagga Bay occupies a considerable area to the west of Crown Point and is physiographically the southernmost boundary of the lake.

Northward from Bulwagga Bay the depth of water in the lake rapidly increases until at the point opposite Essex, some 20 miles north, the deepest water in the lake occurs. From Crown Point north to Split Rock Point the two shores of the lake are markedly different, that on the New York side being mountainous, with summits rising from 1,000 to 1,600 feet above the lake, while that on the Vermont side is decidedly flat, and even swampy around the mouths of Otter, Little Otter, and Lewis creeks. Northward from Split Rock Point the country on both sides of the lake is exceedingly attractive, although the mountains do not approach the shores on either side. On the New York side the country northward from Split Rock Mountain to the end of Willsboro Point is rolling, arable land, while that on the Vermont shore is of the same general character already noticed along the more southerly portions of the lake.

The western side of Willsboro Bay is especially marked by precipitous mountains which rise almost perpendicularly to a considerable height, forming exceptionally bold shores. This mountainous shore continues to Trembleau Point, which has been described as the eastern abutment of the largest of the Adirondack ranges. From this region north on both sides of the lake the country is rolling and the lake is dotted with many islands, some of which, like Grand Isle, are large.

Grand Isle, together with North Hero, Isle La Motte, and Alburg Tongue, form a continuous series which divides the lake into two portions. The easternmost division extends into Canada, covering there an area of 740 square miles. This portion has no outlet, it being an immense bay tributary to and not so deep as the western portion. Its banks are low and the shore is a continuation of broad shoals. The western portion of the lake is the artery of traffic, and the country bordering is of a flat, rolling character similar to that already described.

The lake finally discharges through Richelieu River into the St. Lawrence. Therefore, the general trend of the lake current is northward. Actual movement northward is perceptible with the aid of floats only in the midportions of the broad lake where there are no near-by points of land to cause deflection. On still days floats make very good progress northward, a movement, however, which is interrupted by the slightest stirring of north wind. Movements of the subsurface waters have not been studied. The current next to the shores, however, is almost invariably southward. This is especially noticeable at the mouths of the various tributary streams. In every case which the author examined the water of the streams is deflected

A. RUINS OF CROWN POINT FORTRESS.

B. WASTE TROUGH CROSSING BOUQUET RIVER AT WILLSBORO MILL.

south when conditions are normal—that is, when there is no wind. Worthy of special note is the fact that almost invariably the great sand bars at the mouths of the streams lie to the south, and whenever the water in the streams becomes turbid its course can be readily traced around the points of these bars and thence to the south, spreading ever wider and thinner until its course is no longer perceptible. Where and how this southern current is reversed and merges into the broad lake current has not been determined. The importance of the observation in this report will be noted later in connection with the studies of the wastes and their courses in the lake.

The lake intercepts many and varied geologic formations, each of which has its peculiar effect upon the character of the water immediately surrounding. It is so narrow in proportion to its length that little or no opportunity is afforded for the water draining from the several sides of the basin to become mixed; therefore, there is less uniformity in the character of the ingredients and in their proportion one to another than is usually found in lakes of similar basin capacity, but of more uniform shape. This feature is important in connection with a study of pollution, and necessitates wider investigation and more subtle interpretation than is usually necessary in an investigation of this character. In considering the effect of polluting materials of one kind or another upon a natural water it is necessary to give due regard to the character of that water. Where a given impurity will have a certain effect upon water of one kind it may have a different and possibly opposite effect upon water of another kind.

The variations in the character of water taken from various parts of Lake Champlain are so broad and the physical conditions are so dissimilar that it is necessary to interpret results differently in different portions of the lake. For example, Ticonderoga Creek and Bouquet River each carry to the lake the wastes from a soda-pulp mill. As subsequent study of the conditions will show, the wastes which are derived from these two mills are practically identical. Nevertheless, the effect of the Ticonderoga wastes upon the water of Lake Champlain differs from that of the Bouquet, the reason being that the part of the lake into which Ticonderoga Creek empties is markedly different from that into which the Bouquet discharges.

The time at the disposal of the author was not sufficient to enable him to make a continuous study of the physical, chemical, and biological changes and variations which take place in the lake from point to point, it being necessary to confine the investigation to the specific matters which led to the investigation and to leave the study of other problems in abeyance until some future period. The investigations hereinafter described were therefore made with little or no reference to one another or to the general conditions which obtain in the lake other than those necessary to an intelligent interpretation.

CHARACTERISTICS OF THE LAKE WATER.

It was necessary to secure some data concerning the normal water of the lake, or rather to secure as good an idea as possible of what the lake water would be if it were well mixed and the various ingredients uniform in proportion. For this purpose samples were collected in those portions of the broad lake which seemed to be least affected by polluting influences, whether natural or artificial.

TABLE III.—*Inorganic and sanitary analyses of water from Lake Champlain.*

Sampling point.	SiO_2.	$Fe_2O_3 + Al_2O_3$.	CaO.	MgO.	Na_2O.	Cl.	SO_3.	CO_2.	O rep. by Cl.	Total solids.	Alk.
Gull Island Reef	4.8	1.8	19.19	4.72	8.2	1.1	6.0	22.66	0.479	67.973	47
2 miles north of Four Brother Islands	3.2	.8	19.19	4.72	8.89	1.2	5.8	22.58	.542	65.838	46
Mouth of Willsboro Bay	3.4	.8	22.20	5.13	7.41	1.2	7.1	23.63	.542	70.329	47
New York shore, Chesterfield Township	4.4	1.0	20.01	4.63	8.35	1.4	5.5	22.83	.63	67.49	47
½ mile east of Four Brother Islands	3.0	1.0	19.42	4.45	7.14	1.1	6.6	20.60	.497	62.81	47
Average	3.76	1.08	20.00	4.73	8.2	1.2	6.2	22.46	.542	66.89	47

Sampling point.	Total solids.	Loss on ignition.	Per cent of loss to total.	Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.	Chlorine.	Hardness.	B. coli-com.
1½ miles north of Split Rock	67.0	20.0	30.0	0.130	0.042	0.002	0.100	1.0	51.4	None.
2 miles south of Quaker Smith	72.5	26.0	36.6	.132	.038	.002	.080	1.0	50.0	None.
1½ miles east of Jones Point	63.2	21.0	32.8	.120	.028	.002	.090	.8	50.0	None.
1 mile south of Juniper Island	65.0	22.0	33.8	.156	.032	.002	.100	.8	51.4	None.
1 mile west of Four Brother Islands	60.2	20.0	30.9	.122	.014	.001	.090	.9	50.0	None.
Average	65.6	21.8	32.8	.132	.031	.002	.092	.9	50.6	None.

Examination of Table III will afford an accurate idea concerning such water. It will be noted at the outset that the water contains a fairly high proportion of dissolved solids for this part of the country. Where in this case the water contained from 63 to 70 parts per million of total solids, Lake Winnepesaukee in New Hampshire contains 20 parts; Rangeley Lakes, in Maine, 25 to 26 parts; Moosehead Lake, in the same State, 23 to 24 parts; while the various smaller lakes and reservoirs in Massachusetts contain from 18 to 37 parts of dissolved matter per million.

The analyses given in the table further show that the quantities of lime and magnesia found in the water are extremely high for this part of the country, the lime running from 19 to 22 parts per million, while that in the water of Rangeley and Moosehead lakes is approximately from 2.2 to 2.5 parts. The amounts of iron, aluminum, and silica are fairly large, while the proportion of soda is far higher than in any other surface water of New England. It is essentially a carbon-

ate water, although the amount of sulphate contained in it is proportionately somewhat greater than is usually found in this part of the United States. The chlorides are high, exceeding by about 100 per cent the normal chlorides for this region.

The sanitary analysis shows that the water contains a small amount of organic matter. The fact that the amount of chlorine is above the normal for this section is unmistakable evidence that the water has been polluted. Indeed, it is not necessary to refer to an analysis to determine this point. But the amount of organic matter in the samples under investigation certainly indicates that the water in the broad lake is of satisfactory quality. The amount of albuminoid and free ammonia is considerably less than that contained in several normal surface waters of New England, while the nitrites and nitrates give insignificant testimony, save that in the case of the latter it is shown that oxidation has been rapid and abundant. No bacteria of intestinal origin were found in this water. As might be expected from the large amount of calcium and magnesium noted in the inorganic analyses discussed above, the water is very much harder than that generally found throughout New England, the hardness determined by the soap method being, on the average, 50 parts per million, against 2 to 12 parts in the lakes and reservoirs of New Hampshire, Massachusetts, and Maine.

Although the character of the water in Lake Champlain is variable according to the point from which the water is derived, it is believed that the standards set forth in the table are representative of the water in the broad lake and that they can be used for purposes of comparison in the studies with reference to the effect of soda-pulp-mill pollution from Bouquet River, sulphite-pulp-mill pollution from Ausable River, and sewage pollution from the city of Burlington and Winooski River. In considering the effects of the soda mill upon Ticonderoga Creek, which will complete this report, another standard presented in subsequent pages will be adopted for comparison.

BOUQUET RIVER.

ORIGIN, COURSE, AND FLOW.

Bouquet River is a small Adirondack stream rising in Keene Township, Essex County, N. Y., in the Adirondack Mountain Reserve at the foot of Dix Mountain. Its source is at an elevation of about 3,500 feet above sea level, in a ravine known as Hunters Pass. It flows in a general northwesterly direction, and is joined by South Fork near the point at which the river crosses the Keene Township line into Elizabethtown. Continuing northwestward the stream emerges from the mountain gorges and flows for several miles in a broad, open valley, known as Pleasant Valley, until it reaches Elizabethtown, the

county seat of Essex County. Thence it flows in a general northwesterly direction across the outlying ranges of the Adirondacks and finally emerges upon the rolling table-land (Pl. III, *A*) next to Lake Champlain at Whallonsburg, a village in Essex Township; thence its course is almost due north to Willsboro village, where it takes a sharp bend to the southeast and enters Lake Champlain. About 8 miles from its mouth it is joined by North Branch, which drains a considerable area in Chesterfield and Lewis townships, in the heart of the Adirondacks.

The Bouquet system is useful in a small way, for its rapid descent affords opportunity for many small powers, some of which are utilized for sawmills. The largest power along the stream is about 3 miles from the mouth, at Willsboro village, where there is a fall of about 30 feet, utilized by a saw and grist mill and by the Champlain mills of the New York and Pennsylvania Company (Pl. III, *B*), which are devoted to the manufacture of "soda pulp." Throughout its course the river drains a sparsely inhabited region, the few villages along its banks contributing very little contaminating matter. Above Willsboro the principal source of pollution is sawmills, from which immense quantities of sawdust are turned into the stream during every season. In this respect Bouquet River is similar to almost every other stream which runs out of the Adirondack Mountains. The importance of this will be discussed in subsequent pages.

The flow of Bouquet River fluctuates widely with the season. At times it sustains violent floods, while on the other hand seasons of low water are extreme. The only flow measurements which have been made were carried on during the prosecution of the investigations here reported. The data acquired were collected during an extremely dry season, and afford an excellent idea of the minimum amount of water which the stream may be expected to carry. For this reason the records are valuable in connection with the pollution investigation, for computations based upon them will represent the most grievous conditions from the standpoint of pollution. Effects and deductions made from them will therefore be based upon extreme conditions.

Table IV contains a record of the flow of Bouquet River during a period specified.

A. BOUQUET RIVER ABOVE WILLSBORO.

B. FALLS IN BOUQUET RIVER AT WILLSBORO.

TABLE IV.—*Mean daily discharge of Bouquet River, in cubic feet per second, at Willsboro, N. Y., August 2 to September 3, 1904.*

Date.	Discharge.	Date.	Discharge.
August 2	92	August 19	89
August 3	99	August 20	89
August 4	92	August 21	601
August 5	92	August 22	283
August 6	89	August 23	169
August 7	89	August 24	169
August 8	89	August 25	109
August 9	89	August 26	98
August 10	89	August 27	89
August 11	89	August 28	89
August 12	89	August 29	89
August 13	89	August 30	92
August 14	89	August 31	89
August 15	89	September 1	89
August 16	89	September 2	89
August 17	89	September 3	89
August 18	89		

SODA-PULP POLLUTION.

CONSTITUENTS OF THE PULP.

Wood pulp consists mainly of finely divided cellulose and is the essential constituent of a certain class of paper. It is manufactured either mechanically or chemically. Mechanical pulp is finely ground wood, made by exposing the wood under heavy pressure to the surface of a revolving grindstone, which results in tearing the wood fibers apart. As this kind of pulp contains all the wood ingredients, there is no waste from the process save varying amounts of the fiber itself which escape in the process of handling. Chemical pulp, on the other hand, is made by dissolving out of the wood all the ingredients except the cellulose and leaving the latter in nearly pure state. It follows that this process results in two products—the cellulose or pulp, and the extractives. The former is the real product and the latter the by-product or waste.

Cellulose is the most abundant constituent of plant life and forms the structure of all plant forms. It may be described as the framework by which the plant raises itself and maintains its form and position. To external agencies cellulose is extremely resistant; in fact, it is one of the most chemically inert bodies occurring in nature. It is composed of 44.2 parts of carbon, 6.3 parts of hydrogen, and 49.5

parts of oxygen—a combination so stable that only the most violent chemical methods will change its character. This fact is important because, as will be seen in subsequent pages, wood pulp forms a considerable proportion of the waste from some pulp mills, and because, like all other substances, its final effect upon a stream or other body of water into which it is turned as waste is determined by its stability and its resistance to putrefactive changes.

On the other hand, the extractives of wood—that is, those substances which are separated from the cellulose in the process of wood-pulp manufacture—are organic compounds of an extremely unstable nature, undergoing putrefactive changes readily. It will therefore be appreciated that in the consideration of damage done to watercourses by pulp mills, the attention must be devoted to the extractives rather than to the inert and resistant cellulose.

In investigations of this character it is desirable to determine certain stable and persistent substances in the waste and to direct the investigation toward the identification of those substances in the water rather than to conduct the promiscuous chemical examinations so frequently resorted to in such cases in the hope that the data derived may finally produce something which bears upon the object in view. Therefore in this investigation, as well as in others reviewed in subsequent pages, it will be the endeavor to determine the most characteristic and most stable foreign substances in the waste, and to trace them directly into the lake. In order that the wastes turned into Lake Champlain through Bouquet River from the Willsboro pulp mill may be identified and their effect intelligently interpreted, it will be necessary to consider in some detail the actual process of soda-pulp manufacture.

MANUFACTURE OF SODA PULP.

In considering the process of soda-pulp manufacture, that employed at the Willsboro mill will be taken as a typical example. Although it differs in some respects from the method followed at other mills, as does that followed at any other mill differ from every other, all are essentially similar.

In the case of this mill (Pl. IV, *A*) the process used is based upon the hydrolytic treatment of wood chips at a high temperature in the presence of caustic soda. The process extends to a virtual isolation of the cellulose and the conversion of the extractives or lignone into soluble form. The process is similar to that which has been employed for many years in the recovery of cellulose from materials other than wood, and in the case of wood is adapted only to the conversion of soft species, poplar being used almost exclusively.

A. SODA PULP MILL AT WILLSBORO.

B. AUSABLE CHASM.

WATER USED.

The mills at Willsboro are made up of several structures, some of which are used in the actual manufacture of pulp for paper products, while others are used to carry on certain appurtenant processes involved in the recovery of valuable products and their preparation for further use in the industry. It will be helpful to remark at the outset that the various details of the whole system of manufactures are so correlated that in numerous instances the liquid wastes which are the result of certain treatment are either pumped back to repeat their duty or are used in some other treatment. Therefore the total amount of water consumed in the various treatments is apparently far greater than that supplied to the mill.

A mechanical filter installed at the plant is used to clarify all the water supplied for manufacturing purposes. Measurements of the amount of water drawn from the clear-water basin show that the consumption is equivalent to an average of about 800,000 gallons per day. This water represents the total amount which enters into the manufacturing processes from which wastes are derived.

On the other hand, there is so large an amount of water evaporated during the various stages of the processes from crude wood to finished pulp that the amount of tailings finally turned into the sedimentation beds and into the stream direct is not so great as the amount supplied as clear water by the filters. Assuming, however, that the liquid wastes turned into the stream amount to the entire 800,000 gallons, and basing a calculation upon the minimum flow of Bouquet River, shown in Table IV, namely, 89 cubic feet per second, the proportion of mill waste to water flowing in the stream is about 1 to 72; that is, with the river flowing 89 cubic feet per second, a very low stage, there is 72 times as much water in the stream as is turned in from the mill. During the greater part of the year, when the stream carries a far greater quantity of water, the proportion of waste to water is considerably less, and in floods it probably becomes negligible.

SUPPLIES AND WASTES.

Poplar logs, 4 feet in length, are cut to thin shavings or chips in a chipper and are carried by air blast to a storage bin in the top of the digester house. From this bin the chips are dropped through properly constructed flues into the digesters. The digesters, 4 in number, are 27 feet high, 7 feet wide, and have a capacity of 3,848 cubic feet. Each charge of chips consists of approximately 4 cords, which, when digested, make about 4,500 pounds of dry pulp. Upon each chip charge are poured 3,600 gallons of caustic-soda solution having a specific gravity of 1.081 (11° Baumé or 16.42° Twaddell). This corresponds to approximately 6 per cent of Na_2O. The mass is digested eight hours at a pressure of 110 pounds of steam.

After the digestion process is completed the pulp is forced under pressure into a blow pit, whence it is taken into large wash pans and thoroughly washed. The drainage from these wash pans is designated "first liquid effluent" in this description. Its disposal will be considered hereinafter.

Sufficient water is allowed to remain in the wash pans with the pulp to reduce the whole mass to a fluid state, so that it will run by gravity through pipes without clogging. In the mill under discussion the pulp is conducted through an 8-inch pipe to another building, where it is run across sieves to remove the coarse, undigested particles. More water is added to that already mixed with the pulp, and as the mass is dashed across the mesh the efficiency of the process is increased by agitation of the sieves. The finer pulp which passes the sieves is then pumped with the same water with which it passed upon the sieves to a washer.

The washer is an oblong box about 2 feet deep, in which are 3 rotary screens, octagonal in cross section, set with their longitudinal axes horizontal. Their dimensions are such that the distance from the rotary axis to the perimeter is nearly equal to the depth of the box. This axle is set on the upper edges of the box sides. The sieve surfaces are of brass wire, 60 meshes to the inch. As the pulp passes along under the rotating sieves, the water is separated from it and pours from the sieve ends into a side trough. The pulp passes along under all three rotary sieves and is discharged into a small tank at the end of the washer box. The wash water which passes out of the sieves into the side trough will be designated the "second liquid effluent" and its disposal will be considered on subsequent pages.

Into the small tank which receives the wet pulp from the washer the bleach water, a solution of chloride of lime having a specific gravity of 1.0211 (3° Baumé, 4.22° Twaddell), is turned. The quantity of bleach water used is equivalent to the proportion of 11 pounds of bleaching powder to 100 pounds of pulp. From this mixing tank the pulp is carried to the bleach vats, which, in the mill under discussion, are 3 in number, each 18 feet deep and 15 feet in diameter. The vats are fitted with revolving arms, which effect a thorough mixture of the bleach solution and pulp. The bleaching process consumes from six to eight hours, the end being determined by the appearance of the pulp. When the bleach is complete the mass is reduced to a more fluid state by the addition of water, and the whole is pumped into large draining vats, fitted with porous bottoms through which the water runs, leaving the bleached pulp in a fairly solid state. The drainage water will be designated the "third liquid effluent" and its disposal will be considered later.

When the bleached pulp is thoroughly drained it is again loosened by a stream of water and pumped into a large storage vat, from which

it is taken when needed, mixed in a small tank to the proper consistency with more water, and carried to fine sieves where the coarser particles which occasionally pass the first screening are removed. The material which passes this screen is then carried to the cylinder machine and is felted in the usual manner. The water with which the pulp is loosened in the bleach-drain vats, that which is run into the small mixing tank, and that supplied to the Fourdrinier machine, all take the same course and will be here designated the "fourth liquid effluent," the disposal of which will be considered in subsequent pages.

The above description includes the essential features of the process of pulp manufacture as carried on at the mills of the New York and Pennsylvania Company at Willsboro, N. Y. A summary of the materials supplied to and those drawn from the process may be expressed as follows: Supplies—wood chips, caustic soda, bleach liquor, and wash water; products—first, second, third, and fourth liquid effluents and wood pulp.

The caustic soda and bleach liquor supplied are prepared in appurtenant parts of the mill, and the wastes involved in their preparation are among the most important from the standpoint of stream pollution. The preparation of the caustic is, however, a result of the disposal of the first liquid effluent; therefore the consideration of both caustic and bleach will be postponed until after the discussion of the four liquid effluents.

FIRST LIQUID EFFLUENT.

The water drained from the wash pans after the washing of the newly digested pulp is a complex solution of dark color. Its principal ingredients are caustic soda, lignin, and various other wood extractives. It is of various degrees of concentration, according as it is drained from first washings or from later ones, the drainings from the first washings, as may be expected, being considerably stronger than those from later ones. The washing process used at the Willsboro mill consists of storing drainage water in tanks and using it again for the same purpose until the degree of concentration is sufficiently high to permit an economical recovery of the soda. The process may be described as follows:

Three tanks are provided, to each of which runs a pipe from the wash pans. Into the first tank is conducted the strong liquor which drains from the pulp as it comes from the blow pit. The specific gravity of this liquor is about 1.0765 (10.3° Baumé, 15.3° Twaddell). From this first tank it is pumped back into the blow pit, where it is used to reduce the digested pulp to a fluid state, so that it will readily flow through pipes and valves without clogging. In other words, the sole use of the contents of this tank is to liquefy the contents of the blow pit. After the first liquor is drained from the wash pan, wash

water is turned upon the pulp and the drainings are turned into tank No. 2. At first the specific gravity of this liquor is about 1.0688 (9.33° Baumé, 13.76° Twaddell), but it is gradually diluted as more wash water is turned in. When the concentration has been so reduced that the liquor has a specific gravity of 1.0457 (6.33° Baumé, 9.14° Twaddell) the remainder of the drainings are turned into tank No. 3. The contents of tank No. 2 are conducted to the soda-recovery plant.

Tank No. 3 contains the drainage from the wash pans, which by dilution has been reduced to a concentration of 6° Baumé and below. The contents are used to wash the pulp after the strong liquor has been drained into No. 1, and when again drained from the wash pans it is turned into tank No. 2. This process saves the small amount of soda still contained in the final washings, and when applying it again to an unwashed pulp the liquor is again concentrated sufficiently for use in tank No. 2 and in the recovery process. The final washings of the pulp, the drainage from which is carried into tank No. 3, are made with condensed water from the Yaryan evaporators in the soda-recovery plant. The digesting and pulp-washing processes, above described, afford no waste liquors save the dripping from leaky pipe joints, valves, etc., which occasionally spring, but are of necessity repaired almost immediately. A summary of the supply and discharge from this mill is as follows: Supply—wood chips, caustic soda, distilled water, and steam; discharge—crude pulp and soda liquors. As described on previous pages, the pulp is carried across to the sieves, while the contents of the liquors, a valuable by-product, are recovered.

Recovery of soda.—The contents of tank No. 2, which have a specific gravity of 1.0457 to 1.0688 (6° to 9° Baumé, 4.22° to 8.64° Twaddell), are then evaporated in Yaryan evaporators until concentrated to a specific gravity of 1.2832 to 1.3063 (32° to 34° Baumé, 56.64° to 61.26° Twaddell). The concentrate is then turned into rotary furnaces, where the lignin and other organic materials are burned off. The residue, issuing from the opposite end of the furnace, is composed almost entirely of carbon and sodium carbonate. This substance, known in the trade as black ash, is then passed through a leaching process, the liquid or recovered soda being conducted to the causticizing plant, while the sludge, known as black-ash sludge, remains in the bleaching tanks and is subsequently washed out with water and carried away as waste. This, then, is the *first soda-mill waste* met with in this discussion. The solution of recovered soda which is carried to the causticizing plant varies in specific gravity from 1.2572 to 0 (29.66° to 0° Baumé, 51.44° to 0° Twaddell), according to the leaching period.

The black-ash sludge usually contains a small amount of unleached soda. In the sample tested it was found to be equal to 171 parts per

million—commercially an infinitesimal amount. It is probable that this black-ash sludge may profitably be used as fuel. Preliminary tests are favorable, but the final results of the determination of calorific value have not been received at date of writing.

During the years 1896 to 1903, inclusive, there were used at this mill 89,052,686 pounds of soda ash, of which 87.31 per cent, or 77,747,881 pounds, were recovered soda, leaving only 11,304,805 pounds of fresh ash purchased and applied during the entire eight-year period.

How much of this 12.69 per cent of soda ash which was not recovered at this mill during the above-mentioned period was turned into the stream can not be definitely determined. There is a considerable loss by passage of the soda to the outer air through the flues. Ash from the recovery-plant flue, which settles upon the ground about the plant, contains a large proportion of soda. The amount lost in this way has been computed by some as high as 5 per cent, but so far as the author is able to learn no positive determinations have been made.

There is usually found, in the product of this mill, about 0.112 per cent of soda. This would amount, in the eight-year period above mentioned, upon the basis of the total output—90,022,411 pounds of pulp—to 100,825 pounds. Tests show that the lime sludge from the causticizing tank, a process to be described, contains 0.0327 per cent of soda.

SECOND, THIRD, AND FOURTH LIQUID EFFLUENTS.

The second effluent, as it enters the sieves and wash tank, is derived from two principal sources. It is composed partly of the wash water turned into it in the final washings in the digester house. The origin of this water, as was stated in preceding pages, is the evaporators in the soda-recovery plant. The remaining part of the second liquid effluent consists of spent and weak bleach liquors, which are pumped from beneath the bleach drainers. There is a general interchange of this liquor between one process and another. From each process the liquor is carried to a weir tank in the basement of the mill, whence all the water that is needed in these processes is pumped back for use, while the excess is allowed to escape over the weir directly into the stream. A fair sample of this liquor, taken from the weir tank, contains, among others, the following ingredients:

Partial analysis of second liquid effluent.

	Parts per million.
Calcium	347
Magnesium	7.6
Sodium	13.6
Chlorine	513

Although this liquor contains a considerable amount of lime, soda, and chlorine, the total amount of liquor discharged directly into the

stream is so small that its effect need not be considered apart from that of the entire waste.

The third liquid effluent is conducted through pipes, appears again as second liquid effluent, and takes the course outlined for that effluent.

The fourth liquid effluent is used in the process which produces the third effluent, and the course is repeated.

Thus it is seen that the second, third, and fourth liquid effluents are practically the same, taking the same course, and are repeatedly pumped for further duty.

CAUSTICIZING PROCESS.

This process consists of converting the soda which is recovered in the form of a carbonate, by methods above described, to a hydrate or a caustic soda, by the application of caustic lime. The process is a very simple one, requiring only the addition of an appropriate and easily determined amount of caustic lime to a similarly appropriate amount of sodium-carbonate solution, and boiling the whole mass. The result is a sodium hydrate or caustic soda in the solution, while the calcium carbonate or common lime remains in the bottom of the container as a heavy sludge. The solution is drawn off, ready for use in the digestion process, while the sludge is discharged into the sedimentation bed. This sludge is the *second waste* noted in this discussion. The first causticization leaves considerable amounts of soda in the lime sludge, and repeated washings are necessary to dissolve all except negligible amounts. In the mill under discussion 5 washings are resorted to and 5 cylindrical causticizing tanks are provided, each 12 feet in diameter and 10 feet deep, and the whole series is so manipulated that the causticizing and washing processes form a continuous cycle. It will be necessary to study this cycle in some detail in order that the practical absence of soda in the lime sludge discharged into the sedimentation beds may be explained.

The black-ash liquor, leached out in the recovery plant, is run into tank No. 1. As it comes from the leach it has a specific gravity of 1.2393 to 1.2609 (28° to 30° Baumé, 47.86° to 52.18° Twaddell), but during the latter part of the leaching run the concentration becomes reduced to about 1.0284 (4° Baumé, 5.68° Twaddell). As fast as the black-ash liquor accumulates in the causticizing tank, barrels of caustic lime are added until the tank is nearly full. This requires 17 to 18 barrels of lime. The contents of the tank are then agitated and boiled, and the first stage of the process is complete.

While this process has been going on the lime sludge, in another tank, in which the causticization previous to that in tank No. 1 had taken place, has been treated with water, with the result that the tank

contains a solution of "weak" caustic soda. The process will be more clearly described in its orderly sequence in this cycle under discussion. For the present it will merely be necessary for the reader to remember that there is another tank full of weak soda liquor at hand. Whence it comes will appear shortly.

The contents of tank No. 1—that is, the caustic-soda solution, has a degree of concentration equivalent to specific gravity 1.0902 to 1.1417 (12° to 18° Baumé, 18.04° to 28.34° Twaddell). The degree of concentration in the other tank is usually about 1.0507 (7 Baumé, 10.14° Twaddell). For wood-digesting purposes it is necessary to have a caustic-soda concentration equivalent to a specific gravity of 1.0821 (11° Baumé, 16.42° Twaddell); therefore it is merely necessary to mix the strong with the weak, or, as it is called in the trade, the "strong-weak," in the proper proportion to secure the desired specific gravity of 1.0821. For example, if the strong liquor has a concentration of 15° Baumé, while the "strong-weak" has a concentration of 7 , it will be necessary to draw off equal portions of both into the storage tank to produce a mixture of 11° Baumé liquor. It frequently happens that the strong liquor is not sufficiently concentrated to produce a mixture of 11° Baumé liquor if any material amount of "strong-weak" is added. The strong liquor may possess a concentration of about 12° Baumé, while the "strong-weak" may be 8 Baumé. Under such conditions the practice is to increase the degree of concentration of the strong liquor by adding a definite quantity of fresh-soda ash, raising the concentration in this case to 14° Baumé. Then, if the two liquors are mixed in equal proportions, the resultant will be 11 . This, then, constitutes the point of entrance of the fresh-soda ash which compensates for the 12 per cent unrecovered (see page 29). Thus the strength is adjusted according to the conditions found.

The strong liquor having been emptied from tank No. 1, tank No. 2 is then charged and manipulated in the same manner as that above described, while the sludge in tank No. 1 is filled and more soda is extracted from it. No. 1 is now the "strong-weak" tank. Nos. 1 and 2 are adjusted in concentration and drawn together as before. Continuing, No. 3 is filled with the causticizing ingredients and becomes the "strong" tank. No. 2, filled from the second wash of No. 1, becomes the "strong-weak," and No. 1 is treated to its third washing. No. 4 is now made the causticizing tank, No. 3 is filled from No. 2, and No. 2 again filled from No. 1. No. 4 is the "strong," No. 3 the "strong-weak," and both are adjusted and mixed. No. 4 is filled from No. 2, No. 3 from No. 1, and No. 1 refilled, making the fourth washing for No. 1. No. 5 is now made the "strong" tank, No. 4 the "strong-weak," and both are drawn. No. 5 is then filled from No. 3, No. 4 from No. 2, while No. 3 is again filled from No. 1. No. 1 is then filled with water and the sludge contents run upon the waste bed.

It is then filled with the lime and soda for causticizing and becomes the "strong" tank, No. 5 becomes the "strong-weak," and the cycle is again started. No. 5, then, is the tank referred to on page 31 as "another tank," concerning which promise of further elucidation was made.

The process outlined above accomplishes a recovery of all except negligible amounts of soda used in causticizing. Its principle is most important in a consideration of stream pollution from soda-pulp mills, as it disposes of the idea that large amounts of soda are lost in causticizing, to the detriment of the stream.

PRODUCTION OF BLEACH.

The bleach plant consists of two solution tanks, each 9 feet in diameter and 7 feet deep, which are installed over a bleach-storage tank. The solution tanks are fitted with rotary agitators which are used during the preparation of the bleach liquor. In the manipulation of these tanks the governing principle is the same as that enunciated in the foregoing description of the manufacturing process—that is, weak liquors derived from second sludge extractions are used to make the strong solutions. The method of manufacturing bleach liquor at this mill is practically as follows:

Let it be supposed that tank No. 1 contains the sludge remaining after the preparation of a bleach liquor, the liquor itself having been drawn into the storage tank, and that tank No. 2 is empty. Both tanks are filled with water; in tank No. 2 are placed 1,500 pounds of bleaching powder. This is agitated for ten minutes and the suspended matter allowed to settle. The solution which these proportions of water and bleaching powder make is what is known as 3° bleach, equivalent to about 4.48 ounces of bleach per gallon. This bleach is drawn into the storage tank, and immediately thereafter the clear solution from tank No. 1, which, be it remembered, is a second extraction of the lime sludge in that tank, is quickly drawn into tank No. 2, and to this are added 650 pounds of bleaching powder. This amount of fresh bleach, together with that obtained by the second extraction of the sludge in tanks Nos. 1 and 2, makes a 3° bleach. The sludge in tank No. 1 is then wasted. This leaves tank No. 1 empty, and after the bleach has been drawn from tank No. 2 it contains only the sludge. It will be seen that this is the same condition which was described at the outset of this description, save that in this case tank No. 1 is empty, while tank No. 2 contains the sludge of a previous solution. The process is then repeated, the tanks alternating first with original bleach and then with an adjusted bleach.

The process above outlined involves 3 separate applications of water to the bleaching powder, reducing to a minimum the loss of available

A. EFFLUENT WEIR FROM WILLSBORO SEDIMENTATION BED.

B. FALLS AT HEAD OF AUSABLE CHASM.

chlorine. The lime sludge in the tank after the second application of water is the waste of this process. The method of its disposal will be described under another heading.

In the foregoing discussion of the process of pulp manufacture we have traced waste substances as follows:

1. The black-ash sludge and the water in which it is held in suspension.

2. The second, third, and fourth liquid effluents, which, as described, are used repeatedly, and which finally escape by being forced out by fresher waters entering through various processes.

3. The lime sludge from the causticizing process, containing a small amount of soda.

4. The lime sludge from the bleach-liquor process.

In addition to these there are occasional liquors of a similar nature which escape by reason of accidental leaks and drippings, but their quantity is so small that they do not warrant any further attention in this report.

DISPOSAL OF SLUDGE.

SEDIMENTATION BED.

The mill at Willsboro is situated below the second dam at Willsboro Falls. All of the wastes, except the second, are carried across the river in the trough shown in Pl. II, *B*, and are discharged into a sedimentation bed which covers a considerable area along the right bank of the river, from which it is separated by retaining walls. The various waste liquors run the length of the inclosed area, depositing suspended matter in transit, and are finally discharged at the lower end over a weir (Pl. V, *A*), and find their way into Bouquet River. All of the wastes above enumerated, except the second, enter the stream by way of this sedimentation bed. The second, not containing sufficient foreign matter to render it dangerous to any stream or at all important from the standpoint of pollution, is discharged directly into the stream by way of the tailrace.

In determining the effect of this mill upon Lake Champlain the interest centers upon wastes 1, 2, and 4, and it is necessary to determine the result of the mixture of these substances in the bed, and the character of that which flows over the weir into the stream, in order that the important ingredients may be traced in the river and lake.

WASTES.

Waste No. 1.—The black-ash sludge should theoretically be nothing but carbon. The wood is cooked with caustic soda, the resulting products being pulp, excess soda, and the wood extractives. Poplar wood

contains, according to standard analyses, the following substances in the proportions stated:

Analysis of poplar wood.

	Per cent.
Cellulose	67.77
Resin	1.37
Aqueous extract	2.88
Water	12.10
Lignin	20.88

The soda and all the substances occurring in the above analytical statement, except the cellulose, are separated from the cellulose by washing, and the remaining liquid is run through the recovery process. As a matter of fact this liquid contains also certain important quantities of fine pulp, which pass through the screens. A critical examination of the substances which it contains will show that, with the exception of the soda and carbon, they are all of such a nature as to be volatilized or consumed at the high temperatures used in the recovery process. Cellulose and lignin, which make up the greater proportion of wood, are carbohydrates and are destroyed by heat, leaving only carbon in the ash. The other ingredients are either destroyed or pass off in gaseous form, leaving only soda and carbon at the end. The leaching process described separates the greater part of the soda from the residue, although there still remains, according to analyses of the sludge at this mill, an average of 170 parts of soda per million. When this is discharged into the sedimentation bed it is certain that a still further extraction of the soda from the ash is made. Aside from this, however, waste No. 1 has no effect upon the effluent from the bed.

Waste No. 3.—The lime sludge from the causticization process still retains a small amount of soda, about 327 parts per million, according to determinations made of the sludge at this mill. When this is turned into the sedimentation bed it may be expected that the soda still remaining will be dissolved and that an uncertain but small quantity of the lime will also pass into solution.

Waste No. 4.—The lime sludge from the bleach-liquor process may be expected to contain considerable amounts of chlorine, and in fact the samples analyzed did contain an average of 513 parts per million. This sludge deposited in the sedimentation bed may be expected to impart to the effluent considerable chlorine and a certain amount of lime in solution.

From what has been stated above with reference to the three wastes the conclusion may be drawn that lime, soda, and chlorine are the three principal ingredients of the effluent from the sedimentation bed.

This conclusion is fully borne out by the following analytical statement:

TABLE V.—*Partial analysis of effluent from sedimentation bed, Champlain mills, Willsboro, N. Y.*

	Parts per million.		Parts per million.
Total solids	4,230.000	Alkalinity [a]	1,938.000
Calcium	27.020	Albuminoid ammonia	.266
Magnesium	13.700	Free ammonia	.036
Sodium	803.400	Nitrites	.030
Chlorine	143.900	Nitrates	.100

[a] Equivalent to $CaCO_3$.

The exceedingly small amount of organic matter noted in the above table confirms what has been stated with reference to the destruction of organic matter in the process of soda recovery. The most striking feature appearing in the table is the comparatively small amount of lime which is found in solution. This is of great importance because of the fact that a large part of the objection and complaint has been based upon alleged increase of the amount of lime in the lake, to the detriment of various interests, it having been alleged in one case that the lime was the cause of a death. Twenty-seven parts of calcium per million is far below the amount found in the greater part of the water in the United States. While the composition of this waste varies somewhat from day to day, the amount of lime which is contained in it is at all times exceedingly small. This fact should be borne in mind in connection with the results of other examinations reported in the following pages.

EFFICIENCY OF SEDIMENTATION BED.

The efficiency of the sedimentation bed is confined entirely to the separation of the suspended matter from the solution as represented by the effluent. Practically no change takes place in the character of the waste. A physical examination of the effluent shows usually a clear liquor, although at times amounts of suspended matter have been noted. The sedimentation bed provided apparently serves the useful purpose for which it was erected, and, so far as the writer has been able to discover, fulfills all the requirements demanded of it. The imperfections which exist in the bed did not, during the period in which these investigations were made, result in an inferior effluent, but are rather matters of lack of economy, in which the company alone is interested. Therefore this phase of this question does not enter into the subject of pollution.

It is frequently stated, upon what seems to be reliable testimony,

that the walls surrounding the sedimentation bed are not sufficiently high to keep out the spring floods, and that at such times the floods overtop the walls and force out the material which has been deposited there during the previous months from the mill wastes and carry it into Lake Champlain. On the other hand, equally competent testimony denies that such occasions do arise. As the evidence is about equal on both sides, the writer's opinion with regard to this waste will be based on the condition that the sedimentation bed shall be at all times effective in the separation of suspended matter from liquid and shall not at any time be invaded by floods and the contents washed into the lake.

SEDIMENTATION-BED EFFLUENT.

The character of the effluent from the sedimentation beds is therefore the question on which the whole subject of lake pollution hangs. This character, as indicated by the analytical statement given in Table V, is that of a highly alkaline and highly saline liquor. Therefore the specific tests to be made in the water of the lake to determine the presence of this waste are those of alkalinity and chlorine. No other determinations are of value in the specific problems in hand.

EFFECTS OF WASTE ON BOUQUET RIVER AND LAKE CHAMPLAIN.

It will now be in order to follow the effluent from the sedimentation bed into the stream and down to the lake and to note the effects which it exerts upon both.

EFFECT ON BOUQUET RIVER.

Character and extent.—In considering the effect of the waste on Bouquet River it will be instructive to note (1) any changes which may take place in the amount and character of organic matter in the stream, as the results of analyses of the river at several points will be the final test of the statement that the pollution of the stream by soda-mill wastes is not an organic one. In Table VI are set forth determinations of the amount and the condition of organic matter at three points in the stream—the first a considerable distance above Willsboro village, where the water is practically unpolluted; the second below Willsboro but above the pulp mill, and the third a short distance below the point at which the effluent from the sedimentation bed enters the stream.

TABLE VI.—*Sanitary analyses of water in Bouquet River at three points.*

Sampling point.	Total solids.	Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.
1½ miles above Willsboro	65.0	0.114	0.022	0.0	0.300
Below Willsboro, above mill	72.0	.136	.026	.0	.200
Below outlet to sedimentation bed, 1,000 feet	73.0	.114	.026	.0	.200

It will be appreciated, upon examination of the data, that so far as the mill waste is concerned there is absolutely no evidence of any change taking place in the amount of organic matter in the water. The conditions below the outlet of the sedimentation bed, where one might expect the full force of the impurities to be concentrated, are practically the same as those in the river below the village. It is therefore clear that whatever may be the effect of the pulp mills on Bouquet River and Lake Champlain, such effects do not arise from any deposit of organic matter. The waste from these mills is entirely inorganic and can have no relation to anything allied to the subject of specific communicable disease, except, as shown in the report of Mr. Phelps (pp. 111–114), that the waste may prevent the dissemination of such disease.

From an inorganic standpoint, however, there are many interesting changes which take place in the condition of the water in Bouquet River after the waste from the mills has been turned into it. Examination of Table VII will show that there is a marked increase in the amount of calcium, sodium, and chlorine, the increase in the last-mentioned ingredient being more noticeable than any other.

TABLE VII.—*Principal inorganic ingredients in water of Bouquet River at six points.*

Sampling point.	Total solids.	Ca.	Mg.	Na.	Cl.	Alkalinity.
1½ miles above Willsboro Falls	76.8	14.9	4.4	1.2	1.1	50
At falls above mill	75.0	15.1	5.8	1.2	1.1	50
Just below sedimentation bed	154.8	17.9	6.7	3.7	8.5	57
1,000 feet below sedimentation bed	122.0	24.3	4.1	5.9	8.5	57
1,500 feet below sedimentation bed	101.6	17.9	4.3	7.9	8.5	55
2,000 feet below sedimentation bed	99.0	17.9	4.8	7.6	7.9	55

In considering the character of this river water after it has received the waste from this mill, as shown in the analyses presented, it should be remembered that the river at the time the samples were taken was at an extremely low stage, and that during the greater part of the year the proportion of mill waste contained in the water would be far less. The Willsboro mill is operated on a steady basis—that is, the total output per day throughout the year is practically the same, and therefore the same amount of waste may be depended upon each day throughout the different seasons. The concentration of this waste in the river, however, must vary according to the stage of the stream.

It will be instructive to consider briefly how the water in the stream immediately below the sedimentation bed compares, in its proportion of inorganic ingredients, with other waters in the United States which are considered unobjectionable and freely used for drinking purposes.

TABLE VIII.—*Comparison of principal inorganic constituents in water of Bouquet River below sedimentation bed with those in various public water supplies.*

[Parts per million.]

	CaO.	MgO.	Na_2O.	Cl.
Bouquet River	34.0	6.80	7.95	8.50
Yuma, Ariz	39.5	16.59	194.6	172.37
San Diego, Cal	114.8	46.30	266.0	546.00
Los Angeles, Cal	57.8	15.20	40.4	24.30
Pueblo, Colo	80.7	12.30	55.6	20.70
Lake Michigan, Chicago	36.1	11.60	5.5	4.80
Maquoketa, Iowa	83.5	33.70	22.2	33.20
Clinton, Iowa	54.9	21.40	75.0	50.30
Mason City, Iowa	75.2	21.90	4.8	4.60
Rockwell City, Iowa	274.0	87.50	.....	.....
Postville, Iowa	94.5	42.60	9.9	2.30
Council Bluffs, Iowa	46.1	13.80	38.0	8.50
Cedar Rapids, Iowa	70.5	36.10	85.5	26.70
Waterloo, Iowa	32.1	33.80	10.6	4.30
Dodge, Kans	106.8	28.40	78.0	40.30
Topeka, Kans	108.9	22.10	153.3	145.10
Argentine, Kans	74.8	13.70	39.2	41.60
Cumberland, Md	145.2	8.90	8.7	7.00
Minneapolis, Minn	40.2	13.30	.....	.....
Bayonne, N. J	42.7	7.20	7.2	10.90
Mount Vernon, Ohio	76.1	19.10	15.4	4.80
Sioux Falls, S. Dak	98.8	35.60	16.8	3.10
Houston, Tex	56.2	5.00	46.6	48.90
El Paso, Tex	180.1	26.00	450.0	393.00
Winchester, Va	76.9	16.10	3.9	6.00
West Milwaukee, Wis	31.6	10.30	18.1	2.90

Conclusions.—The data set forth above show clearly that, so far as the inorganic ingredients, especially lime, soda, and chlorine are concerned, the water of Bouquet River below the entrance of the waste from Willsboro mill is preferable to many waters which are used daily for domestic purposes and concerning which no complaint is ever heard. It is true, notwithstanding, that the river is damaged by the mill. The waste which is turned into the stream contains a certain amount of wood pulp which passes through the washers and bleach drainers. This pulp is small in amount, yet from day to day it accumulates and in the course of weeks and months represents a considerable loss. It is collected in the eddies and shallow places along the banks of the stream and is found along the shores of the lake

close to the mouth of the river, this latter amount, however, being insignificant. After an extended search along the shores of the lake north and south from the mouth, covering several miles and occupying about one-half day, the amount of pulp found here and there in isolated bunches weighed approximately 5 pounds. In the stream, however, the damage done is readily apparent. Although the pulp itself does not putrefy, it collects and holds large amounts of other débris which is putrescible, with the result that the mass becomes foul and gives off disagreeable odors. There is, too, a characteristic odor in the mill waste which is appreciable all along the stream, and can be detected in the lake at the mouth of the river when the conditions are favorable. This odor permeates the water, and while it can not be regarded as a serious nuisance, it is, nevertheless, somewhat objectionable.

The most serious feature in regard to the waste in the stream is that it gives a distinct and disagreeable taste to the fish, so that they are no longer fit for eating. Contrary to widespread reports, there are fish in this stream in considerable numbers, but their value as food is said to be entirely destroyed.

Realty values along the stream are diminished somewhat; but as there is not at present, nor will there be in the future, any great demand for the property as a place of residence, this damage is more theoretical than practical.

In short, while the stream is undoubtedly damaged by the mill, there is a compensation in the presence of the industry in that neighborhood. On the basis of public economy, there would be no hesitation in choosing in favor of the mill rather than the stream. The damage done is entirely local and probably is not felt from an actual pecuniary standpoint, while, on the other hand, if the mill were closed the loss to the community would be serious.

EFFECT OF WASTE ON LAKE CHAMPLAIN.

The observations which have been made with reference to the river and the effect which the mill waste exerts upon it can not be taken as an absolute indication of the effect of these wastes in the lake. Damage to the stream does not necessarily involve damage to the lake, nor, on the other hand, would a lack of damage to the former be an assurance of no damage to the latter. It is only upon actual investigation, involving the patient tracing out of the specific foreign ingredients in the waters of the lake, and observing the distance from the mouth of the river at which the lake water assumes the normal characteristics shown in Table III, that any definite statements can be made with reference to the subject.

Methods of investigation.—In the investigations here reported it has been the endeavor to work out the problem along these precise lines.

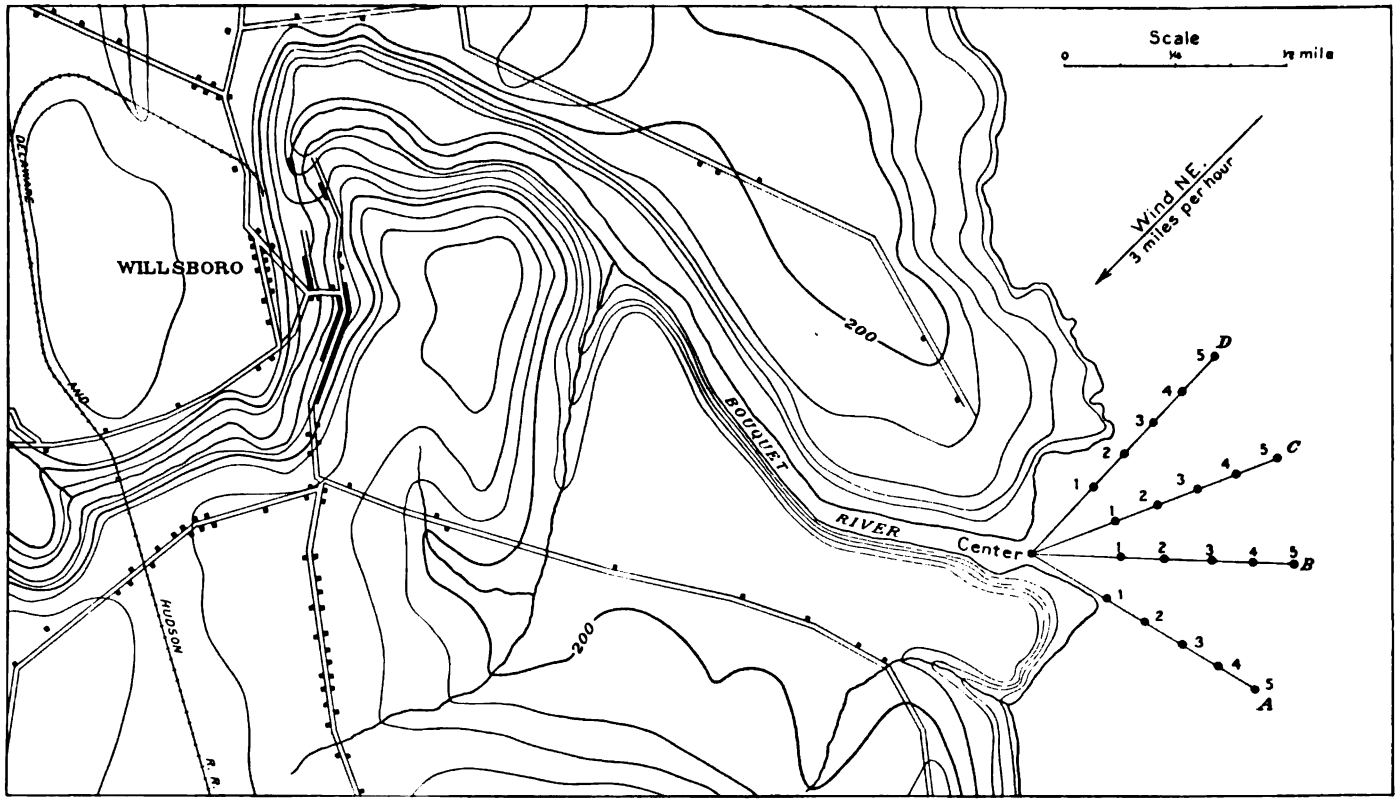
Samples have been taken of the water at the mouth of the river and from this point along radiating lines running well out into the lake. These, together with the samples taken along the shore north and south of the river, give an accurate idea of the distances to which the mill waste is appreciable. In this way the data for this report have been gathered and the results of the various determinations have been grouped so that they may admit of intelligent interpretation.

The lake at the mouth of Bouquet River is well represented in Pl. VI; the prominent points to the north and to the south of the river define a small bay where the water is extremely shallow. A high sand bar, composed of materials brought down by the river, extends for about one-half mile east of the southernmost point. Between this bar on the south and the bolder cape on the north the sand has drifted, making the water too shallow for any except the smallest light-draft rowboats. Here the river empties its contents and an exceptionally favorable place is afforded for the concentration of the wastes from the pulp mill.

The investigations subsequently to be described consisted of the sampling of water at designated points and determining the amount of chlorine and the alkalinity, expressing the latter in terms of calcium carbonate. These two determinations, as above noted, are the specific ones which are best adapted for tracing the mill waste into the lake.

The initial samples in each case were taken at a central point at the mouth of the river, marked by a buoy, and all other samples were taken along lines radiating from this point, as indicated on Pls. VI, VII, and VIII. The distances between the sampling points were in all but a few cases actually determined by measurement, and buoys were permanently set at these points. In other cases, however, the distances were estimated as closely as possible by observing intersecting lines running over landmarks or by points along the shore. In the case of the shore samples taken in the last two series the distances were approximately 1,000 feet apart.

In all sample series the direction of the wind and the velocity recorded by the anemometer have been considered, and interpretations of the various results should be made according to these conditions. In an experimental series taken on August 2 it was found that the water at the surface was typical of the conditions resulting from the discharge of waste into the lake. The lower waters were, however, more uniform, generally little affected by the wastes, and therefore not good subjects of investigation. Samples were taken in all subsequent series from the surface only, and in interpreting the results hereinafter set forth with reference to the effect of the river upon the lake, it should be remembered that such results set forth only the conditions existing at the surface and that throughout the entire investigation there was



BOUQUET SAMPLE SERIES OF AUGUST 12, 1904.

not, except in the very limited area about the central buoy, any indication of pollution from the stream in the deeper waters of the lake. Therefore the effects of the wind upon the distribution of the wastes are to be recognized more prominently in the direction from the mouth of the river toward which the wind was blowing.

Sample series of August 12.—The conditions attendant upon the collection of this series of samples are well set forth in Pl. VI. There it is shown that a light wind was blowing from the northeast. The water from the river, therefore, might be expected to take a sharp southerly turn, and little or no effect would be discernible along the outer sampling points of lines C and D. Reference to Table IX shows conclusively that such inferences are unreliable. Critical examination of the figures shows that there is a marked increase in chlorides and alkalinity along the D line from center to point 5. This may be explained by the following statement: The 3-mile wind represented on the plate was that which immediately followed a change in wind direction. These samples were taken in the afternoon. The record shows that during the morning and up to about noon a strong wind was blowing from the south, and that such conditions persisted all the day previous. The wastes under these conditions were blown to the north shore, and the wind having changed so short a time before the samples were taken, and having blown so lightly, its effect was not appreciable. The condition under which the samples were taken was in reality a 10-mile wind from the south.

TABLE IX.—*Bouquet River sample series of August 12, 1904.*

[Parts per million.]

Sampling point.	Chlorine.	Alkalinity.	Sampling point.	Chlorine.	Alkalinity.
A LINE.					
Center	7.2	57.0	A–3	1.7	47.0
A–1	6.1	55.0	A–4	1.5	47.0
A–2	1.7	47.0	A–5	1.6	47.0
B LINE.					
Center	7.2	57.0	B–3	1.4	47.0
B–1	1.5	48.0	B–4	1.4	47.0
B–2	1.4	47.0	B–5	1.4	47.0
C LINE.					
Center	7.2	57.0	C–3	1.4	46.0
C–1	1.4	48.0	C–4	1.1	47.0
C–2	1.3	48.0	C–5	1.1	47.0

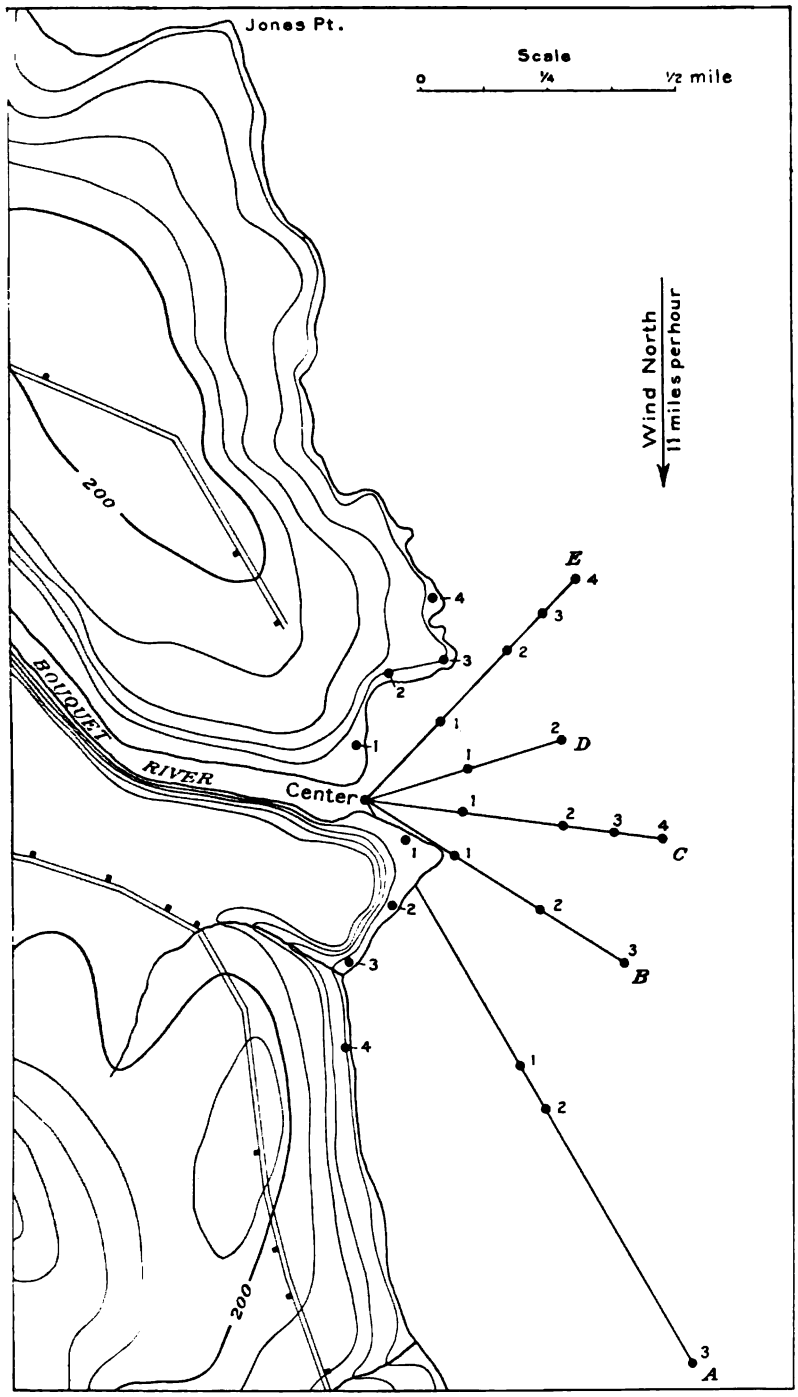
TABLE IX.—*Bouquet River sample series of August 12, 1904*—Continued.

D LINE.

Sampling point.	Chlorine.	Alkalinity.	Sampling point.	Chlorine.	Alkalinity.
Center	7.2	57.0	D–3	1.4	48.0
D–1	1.2	48.0	D–4	4.2	47.0
D–2			D–5	3.3	47.0

In examining Table IX it should be remembered that the chlorides in the water of the broad lake which were stated in Table III (p. 20) as the standard of comparison are 1.2 parts per million, while the alkalinity is 47 parts. The results of the sample series of August 12 show an enormously increased amount of chlorine and alkalinity at the center buoy. Along the A line there is a slight decrease at No. 1, which lies close to a sand bar and is in a position to be markedly affected, while at point No. 2 the conditions are almost normal, the alkalinity being the same as in the center of the lake and the chlorine a trifle higher. These conditions are practically the same for the other three sampling points. Along the B line there is practically no evidence of pollution from the mill at point No. 1, 1,000 feet from the center buoy, while at point No. 2 the alkalinity has reached the normal, while the chlorine exceeds it by an insignificant amount. The same condition persists at points 3, 4, and 5. The evidence given by the C line is the same—that is, that 1,000 feet from the center buoy there appears to be little or no pollution from the stream, while at a distance of 2,500 feet along this line the water is the same as that taken from the broad unpolluted lake. The peculiarity shown by the D line has already been mentioned. The amount of chlorine in the waters at sampling points 4 and 5 is greater than that at 1 and 3. This, as has been said, is due to the strong southerly winds which prevailed during the day previous and the first part of the day on which the samples were taken. Attention should also be called to the shore outline north of the river's mouth, which during a southerly breeze would have the effect of throwing floating impurities out into the lake at about the relative positions occupied by points 3, 4, and 5.

The results of the determination of chlorine and alkalinity in this series of samples indicate that at a distance of 1,000 feet from the center buoy the effect has already practically disappeared at the B and C lines. The same is true of the A line at a point 1,500 feet from the center buoy, the point at 1,000 feet being very near the shore and in shallow water next to the sand bar, while at the D line little trustworthy evidence is afforded because of the peculiar conditions which preceded the taking of the sample. The character of the water at



BOUQUET SAMPLE SERIES OF AUGUST 21, 1904.

points 4 and 5 on this line was abnormal only in the amount of chlorine, which, while considerable, would by no means represent a dangerous water.

Sample series of August 21.—This series was taken during a northerly breeze, blowing at about 11 miles per hour. The surface of the lake was exceedingly rough, as at this point a northerly wind has a sweep of about 50 miles of lake. Samples were taken along 5 radiating lines from the center buoy and along the shore north and south of the river's mouth. Along the A line, as shown in Pl. VII, samples were taken at distances of 2,500, 3,000, and 6,000 feet; along the B line at 1,000, 2,000, 2,500, and 3,000 feet; along the D line at 1,000 and 2,000 feet, and along the E line at 1,000, 2,000, 2,500, and 3,000 feet. The shore samples were taken approximately 1,000 feet apart north and south of the river's mouth. The results of the determinations are set forth in Table X.

TABLE X.—*Bouquet River sample series of August 21, 1904.*

[Parts per million.]

A LINE.

Sampling point.	Chlorine.	Alkalinity.	Sampling point.	Chlorine.	Alkalinity.
Center	1.4	47.0	A-2	1.0	44.0
A-1	1.2	46.5	A-3	.9	43.0

B LINE.

Center	1.4	47.0	B-2	1.1	47.0
B-1	1.2	48.0	B-3	1.0	44.0

C LINE.

Center	1.4	47.0	C-3	0.9	44.0
C-1	1.3	48.0	C-4	1.0	44.0
C-2	1.2	45.0			

D LINE.

Center	1.4	47.0	D-2	1.0	44.0
D-1	1.6	48.0			

E LINE.

Center	1.4	47.0	E-3	0.8	45.0
E-1	1.2	48.0	E-4	1.0	45.0
E-2	1.2	45.0			

TABLE X.—*Bouquet River sample series of August 21, 1904*—Continued.

SOUTH SHORE.

Sampling point.	Chlorine.	Alkalinity.	Sampling point.	Chlorine.	Alkalinity.
Center	1.4	47.0	3	3.5	54.0
1	3.0	56.0	4	3.8	55.0
2	3.3	54.0			

NORTH SHORE.

Center	1.4	47.0	3	1.0	47.0
1	1.0	47.0	4	1.2	45.0
2	2.1	60.0			

The south shore samples, as might be expected, show a considerable concentration of the waste from the stream, the chlorides and the alkalinity being higher than at the center buoy. In fact, the condition of the water at the center buoy in the mouth of the river is remarkable in having an alkalinity not greater than that in the broad lake and an insignificant increase only in the amount of chlorine. There seems, however, to have been a concentration of the waste along the south shore during the same period at which, from one reason or another, the amount of waste running down the stream was greater than during the period at which the sample was taken. The reason for this was not shown in the investigation, as it was demonstrated that the amount of waste turned into the stream had been practically constant for several days previous. The most probable reason for the condition is the effect of the peculiar shore line and the wind.

The A line shows no evidence whatsoever of the presence of waste from the mill, nor does the B line even at a distance of 1,000 feet from the center buoy and around the sand bar mentioned in the discussion of the sample series of August 12. In fact, the samples taken along the various lines as a whole give entirely negative evidence, proving conclusively that the effect of the wastes turned into Bouquet River is not appreciable for any considerable distance into the lake, and that the only apparent effect traceable is alongshore immediately north or south of the river's mouth.

The data afforded by the two sample series above discussed show unmistakably that while the sedimentation bed of the Willsboro mill is in operation, and while care is taken in the operation of the mill, there is no appreciable pollution of Lake Champlain from Bouquet River. In considering matters of this kind the inquiry is usually extended to two broad questions: (1) Whether the foreign matter turned into the stream is appreciable in the lake; and (2) if appreciable,

whether or not its presence is deleterious. In this case, however, it is unnecessary to enter into the second part of the problem. So far as the specific material turned into the river by the mill is concerned it can not be traced by chemical means for any distance into the lake. It has been shown in previous pages that the pollution is a chemical rather than an organic one, and that the substances are lime, soda, and chlorine. It was further shown that the amount of lime even in the effluent from the sedimentation bed is extremely small, and that many lakes, rivers, and water supplies throughout the country contain far more without doing damage. It has been further shown that, as soda and chlorine are the principal polluting constituents, the determinations of chlorine and of alkalinity are the specific determinations for use in the investigation of this class of pollution. The evidence of the sample series of August 12 and 21 demonstrates that no damage results in the lake. These conclusions are made with the reservation that the sedimentation bed at the Willsboro mill shall be in operation and shall work as effectively as it did during the period of the investigation.

Sample series of August 31.—It was believed wise, however, to determine what the effect might be if the sedimentation bed were not operated. This was made all the more desirable because of the oft-repeated statement by the complainants that, although by the introduction of the sedimentation bed the greater part of the ground for complaint against the mill had been removed, the bed had not been operated previous to the commencement of the investigation, and that typical results were not obtained by the author. Arrangements were therefore made with the mill authorities to disconnect the trough shown in Pl. II, *B*, which conducts the wastes across the stream and into the sedimentation bed, and to allow the raw material to run down the river and into the lake for a period of twenty-four hours, at the end of which samples were to be taken and a general series of determinations made to ascertain whether or not the conditions would be materially different from those in the case of the two previous sample series. Accordingly the trough was disconnected at 3.20 p. m. on August 30, and the entire waste from the mill, including black-ash and lime sludges, was allowed to flow into the stream until 5 p. m. on August 31. At 4 p. m. on August 31 a series of samples was taken at the mouth of the river, at positions indicated on the map, Pl. VIII. A northeast wind, blowing at the rate of 10 miles an hour, was piling up the waves across the sampling field and diverting all the flow from the river southward along the shore of the lake.

It did not require chemical analysis to determine the effect of the discharge. From the mouth of the river around the point and south thereof, and thence along the shore in a dark purplish band about 300 feet in width, the mill waste extended down the south shore

for a distance of about 1 mile. Here it ended and the water beyond was of the normal appearance. The results of the investigations in Table XI will show the character of the water.

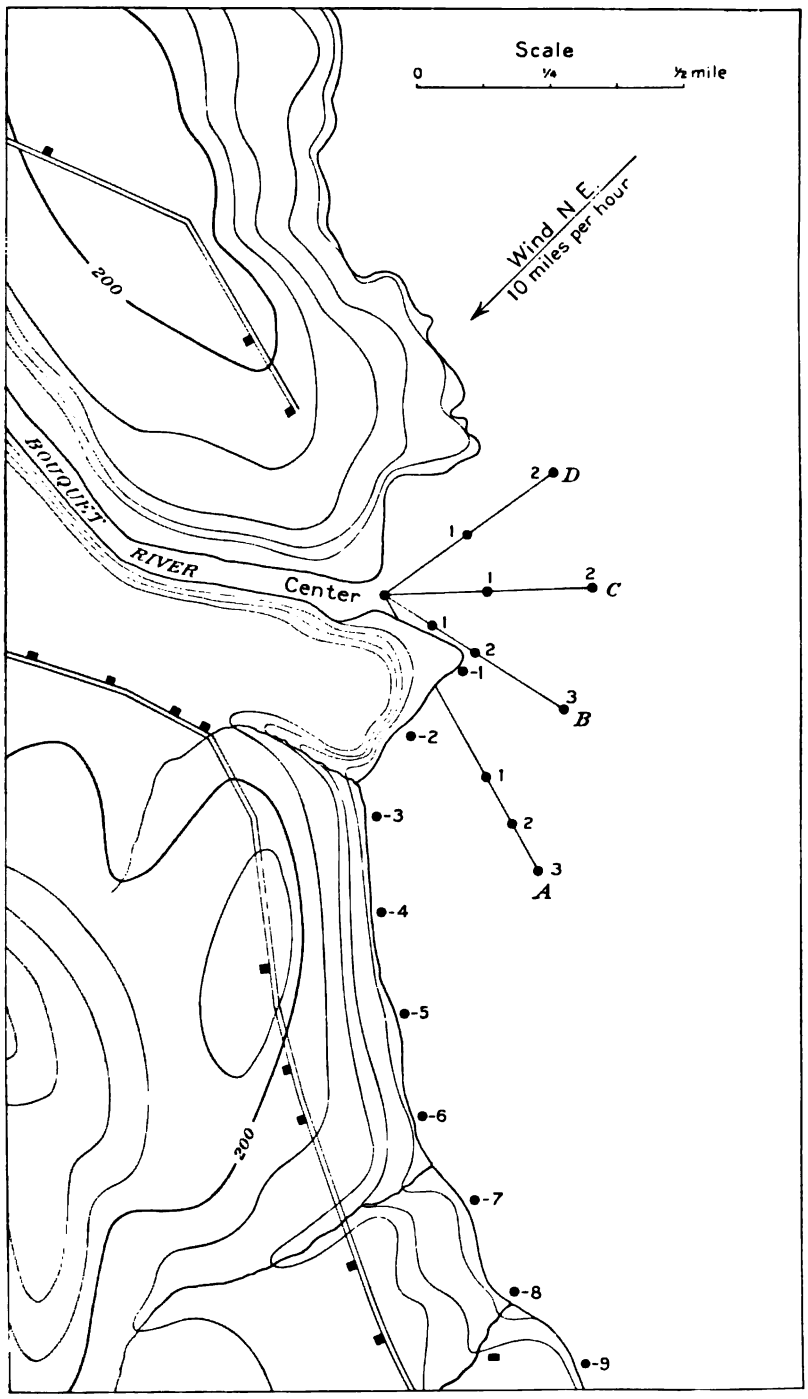
TABLE XI.—*Bouquet River sample series of August 31 and September 2, 1904.*

[Parts per million.]

Sampling point.	Chlorine.	Alkalinity.	Sampling point.	Chlorine.	Alkalinity.
A LINE.[a]					
Center	9.8	59.0	A–2	1.1	45.0
A–1	1.1	45.0	A–3	.9	45.0
B LINE.[a]					
Center	9.8	59.0	B–2	6.2	57.0
B–1	8.9	58.0	B–3	1.1	45.0
C LINE.[a]					
Center	9.8	59.0	C–2	1.5	44.0
C–1	1.3	44.5			
D LINE.[a]					
Center	9.8	59.0	D–2	.9	44.0
D–1	1.2	45.0			
SOUTH SHORE.[a]					
Center	9.8	59.0	5	1.9	46.0
1	5.2	60.5	6	3.2	45.0
2	7.2	54.0	7	1.4	44.0
3	5.2	47.0	8	1.3	45.0
4	4.0	46.0	9	1.1	45.0
SOUTH SHORE.[b]					
1	7.5	53.0	5	1.3	45.0
2	1.6	47.0	6	1.2	44.5
3	1.6	44.5	7	1.1	45.0
4	1.2	44.0	8	1.0	45.0

[a] August 31. [b] September 2.

It will be seen that at the center buoy there was a chlorine content of 9.8 parts per million, with an alkalinity of 59. At the sampling points on the A line, situated at 2,000, 2,500, and 3,000 feet from the



BOUQUET SAMPLE SERIES OF AUGUST 31 1904

center and one-fifth to one-fourth mile from the shore, the chlorine and alkalinity were subnormal. Along the B_1 line, at points 1 and 2, being 500 and 1,000 feet, respectively, from the center buoy and beyond the narrow line of influence of the waste, the water was normal. The samples along line C showed a slight rise in chlorine, but subnormal alkalinity, while no effect along line D was perceptible. Along the south shore line samples from points varying from about 800 to 1,000 feet apart show clearly the effect of the discharge of waste. Sample No. 9 was taken about 50 feet beyond the point at which the visible effect of the waste ended, and, as shown by the determination, is a normal lake water.

The evidence shown by the series of samples and by the observations made at the time of sampling indicates that when the waste is turned from the Willsboro mill directly into the stream the local effects about the mouth of the river are marked. In order to determine how long the condition which was brought about by this direct discharge might persist, a series of samples was taken along the shore two days later, on September 2, which are set forth in the last section of Table XI. They show conclusively that while the results of the discharge of water directly into the stream were not so marked as on August 31, the chlorine and alkalinity were higher than at any time during the previous examinations.

Conclusions.—It is apparent that the daily discharge of the entire amount of mill sludge directly into the stream would, if continued for a long period, affect the lake even more than is indicated by the short-term discharge noted in the above discussion. The deposit of large quantities of lime along the bed of the stream would increase the damage already done there and would seriously affect the lake by reason of its being washed down into it at every freshet. From the results of the experimental discharge it can not be determined with any degree of assurance just what the effect would be, but it is reasonably safe to assume that the conditions for a considerable distance in the lake and to the north and south of the river's mouth would be comparable to those now existing in the stream.

The evidence given on the previous pages is, in the opinion of the author, unquestionably sufficient to support the opinion that the pulp mill at Willsboro has not the slightest harmful effect upon the lake when it is operated in connection with the sedimentation bed. While objection has been raised to the sedimentation bed itself, the statements made have been based upon features which are not necessary to the efficiency of the bed as a separator of suspended material, but rather upon features which should interest only the company maintaining the plant. It is not within the scope of this report to criticise the sedimentation bed or any device which has been set up to prevent the pollution of streams. Strictly, the investigation was limited

to the lake itself, and the limit has been overstepped only when it was necessary to do so in order to intelligently lead up to a discussion of the real problems. Therefore, whatever may be said by way of criticism of the sedimentation bed must be left for other investigations and reports. It is sufficient to state that the plant which is now provided is efficient in caring for the suspended matter in the waste, and that what flows over the lower end of the retaining wall is not of a character to influence in the slightest degree the water of the lake beyond the short distance of from 1,000 to 2,000 feet from the river's mouth.

AUSABLE RIVER.

ORIGIN AND COURSE.

East and West branches of Ausable River join to form the main stream on the northern border of Jay Township. From this point the river flows northwestward to Lake Champlain, forming the boundary between Essex and Clinton counties. The distance between the confluence of the two branches and the mouth of the river is about 20 miles. West Branch of Ausable River rises in Lake Placid, at an elevation of 1,864 feet. East Branch rises in Ausable lakes, in the Adirondack Mountain Reserve, the elevation of the upper lake being 1,993 feet. The main stream enters Lake Champlain at an elevation of 101 feet. From this it may be seen that Ausable River is a fairly good power stream (Pl. V, *B*), although the variable flow makes it somewhat unreliable in dry seasons. Nevertheless, the valley has attracted many industries (Pl. IX, *B*) and has been in the past of considerable importance as an iron-manufacturing center. At the junction of the two branches is the village of Ausable Forks, which was initially developed by the iron industry and later grew by the wood-pulp industry. Six miles below, at Clintonville, there was at one time a fair amount of activity in the iron industry, but this has during recent years failed completely, and the village presents a deserted appearance. Still farther down the stream is the village of Keeseville, a conservative old town, which has developed considerable importance in the past by reason of its various manufacturing plants.

Three miles below this the river enters what is known as Ausable Chasm, a striking feature of that part of the country. It is a very narrow gorge, about 100 feet in depth, and varying in width from 10 to 50 feet, with perpendicular walls. This chasm has been eroded by the stream through the Potsdam sandstone and is well represented in Pl. IV, *B*. Altogether, Ausable River is of considerable importance by reason of its useful and attractive features, and of late the country has been developed more and more extensively as a summer resort.

The river enters Lake Champlain about 3 miles north of Port Kent; the country at its mouth is very low and swampy and of delta-like

A. WOOD PULP AND SAWDUST ON WEST SHORE OF LAKE CHAMPLAIN.

B. FALLS ON AUSABLE RIVER AT KEESEVILLE, N. Y.

formation. At the present time the waters of the river enter the lake by two outlets, and formerly there were several others, a third having been closed by sedimentary deposits within recent years. (See map, Pl. I.)

SULPHITE-PULP POLLUTION.

The principal point of interest for the purposes of this report is at Ausable Forks, where there have been established the extensive pulp and paper mills of the J. & J. Rogers Company. The process by which pulp is manufactured at this plant differs materially from that at Willsboro. The separation of the lignin and other extractives from the cellulose rests upon the action of sulphurous acid, which is applied to the wood in the form of an acid calcium sulphite. In order to determine the character of the waste from the sulphite process it will be necessary to review in some detail the manufacturing process. It is, on the whole, much simpler to describe and involves fewer appurtenant plants than the soda process, while at the same time the by-products are far more complex and present difficulties which up to the present time have baffled the skill of the ablest chemists.

MANUFACTURE OF SULPHITE-PULP.

The manufacture of sulphite pulp differs from that of soda pulp in that the medium by which the wood is digested is an acid sulphite of calcium instead of a caustic soda. This substance is more effective in the disintegration of fiber than is caustic soda, and is therefore used upon tougher and more consolidated woods, notably spruce. In many respects the two processes are similar. The spruce wood used is barked and chipped in the same way, and the chips are turned into the digesters and treated with the liquor in a substantially similar manner.

METHODS OF MANUFACTURE.

The acid sulphite used to disintegrate the cellulose fibers is made in the following manner: Sulphur is burned in furnaces, the air supply of which is regulated, and the sulphur dioxide thus formed is carried over to a cooler, whence it is drawn through a series of three tanks filled with milk of lime. This is generally designated the "vacuum process." The gas is first drawn upward by virtue of a partial vacuum created in the tanks, through the lowest tank, where a part of the gas is absorbed; it is then carried to the next higher; finally it is absorbed by the milk of lime in the third tank. This operation is easily regulated by adjusting the supply of sulphur-dioxide gas and the vacuum in the tanks. Under such a process the lowest tank has the strongest liquor. When it has reached a specific gravity of about 1.0357 (5° Baumé, 7.14° Twaddell) it is drawn off

complaint has been made by the residents of this village because of the undesirable appearance and alleged unhealthfulness of the stream. Undoubtedly there is considerable damage done to the water supply of Keeseville, but under the present conditions there is no doubt that the pulp-mill waste is a benefit to the town. While complaining against the Rogers pulp mill the village has neglected to keep its own skirts clean; at several points above the intake of the waterworks there are private sewers of the most dangerous sort entering the river, and the conditions favoring an extensive typhoid epidemic are ideal. There has, however, been little typhoid fever in Keeseville, because the appearance and odor of the water are so bad that none of the citizens use it for drinking purposes. If it had retained its original appearance—that is, if the sulphite-mill waste had been kept out of the stream—the water would have been used by the majority of the inhabitants, with the fatal results which have been witnessed in so many other American municipalities. Therefore the condition of Ausable River as a result of pulp-mill waste, bad as it undoubtedly is, is an important measure of safety for the people of Keeseville, and before that community can with any propriety take up cudgels against the pulp mill it will be necessary for them to place their own surroundings above suspicion.

Two miles below Ausable Forks a partial analysis was made of Ausable River water. It contained 185.8 parts per million of total solids, of which 119 parts were organic and volatile matter. Strange to say, the amount of calcium was only 13.54 parts, somewhat less than that in the Lake Champlain water. The river, too, had neutralized the acid contributed to it by the sulphite waste. The alkalinity in terms of calcium carbonate amounted to 27 parts per million, considerably less than that of the water of Lake Champlain, and the same as the alkalinity of the water of West Branch above all points of pollution. It is evident, then, that although the principal chemical turned into the stream from the sulphite mill is calcium sulphite, this determination can not be resorted to in tracing the waste into Lake Champlain; for, as was shown above, 2 miles below the point of entrance of the waste the amount of calcium is less than that in the lake. Hence it is apparent that the specific determinations which will most readily distinguish the water of the river from that of the lake are those which will reveal the increase in organic matter. The excess of alkalinity of the water of the lake over that of the river also promises to furnish valuable evidence. These two determinations were therefore selected as specific, and results show that the selection was justified.

Analysis shows that there is no doubt whatever concerning the damaging effect of the waste upon the river. Whether or not this extends into the lake remains to be seen.

EFFECT OF SULPHITE-PULP WASTES ON LAKE CHAMPLAIN.

Ausable River discharges into Lake Champlain over an elevated bench which, even at high water, is only a few feet below the surface. Examination of this bottom and of the shores for several miles north and south of the two mouths of the river shows an enormous accumulation of wood pulp, together with a greater accumulation of sawdust, which is turned into the stream from the many sawmills in the valley (Pl. IX, A). The shallow water lying over the bench carries large amounts of pulp in suspension, and is exceedingly malodorous by reason of its large content of putrescible organic matter.

Methods of investigation.—The investigation was planned along lines somewhat similar to those followed for Bouquet River. Samples were taken in the upper and lower mouths of the river, and from these at intervals along divergent lines running north, south, and east. The various modifying features which prevailed in the case of the Bouquet investigations apply here, especially the effect of the winds blowing at the time of sampling. If the specific determinations decided upon in this investigation are well chosen, we may expect to find that the percentage of volatile solids in the water of the lake will decrease in the progressive samples from the central points, while, on the other hand, the alkalinity of the water (which is greatly reduced by reason of the pouring of the acid water into the river) may be expected to increase as the unpolluted waters of the lake are approached. This will be brought out in detail in the following discussion of the various sample series.

Sample series of August 23.—The samples in this series were distributed along four lines, two running from a center situated at the north mouth of the Ausable and two from a center similarly situated at the south mouth (fig. 1, p. 54). Line D, from the north center, runs almost due east for about 1,500 feet, and then turns northward with a divergence of about 15° east. Sample No. 1 was taken at the bend in line D, while samples Nos. 2, 3, and 4 were taken at 1,500, 6,000, and 11,000 feet, respectively, along the D line from No. 1. Line C was run east by about 10° south, and samples Nos. 1, 2, and 3 were taken at 1,000, 2,500, and 4,500 feet, respectively, from the center. Line B was run from the south center east by about 5° south, and samples were taken at approximately the same intervals as along line C. Line A was run from the south center direct toward Trembleau Point, and thence to the north end of Schuyler Island and around to the south end. Samples were taken along this line as follows: No. 1, 1,000 feet from center; No. 2, 2,500 feet; No. 3, 5,000 feet; No. 4, 8,500 feet; No. 5, 13,000 feet; No. 6, 17,000 feet; No. 7, 20,000 feet; No. 8, 23,000 feet; No. 9, 28,000 feet. Lines A and D were run so much farther from the center on account of the currents in the lake, described on page 18. The prevailing winds for a considerable period

previous to the day of sampling had been either north or south; in fact, during the twenty-four hours previous to the sampling the wind had been blowing from the north at an average rate for the entire period

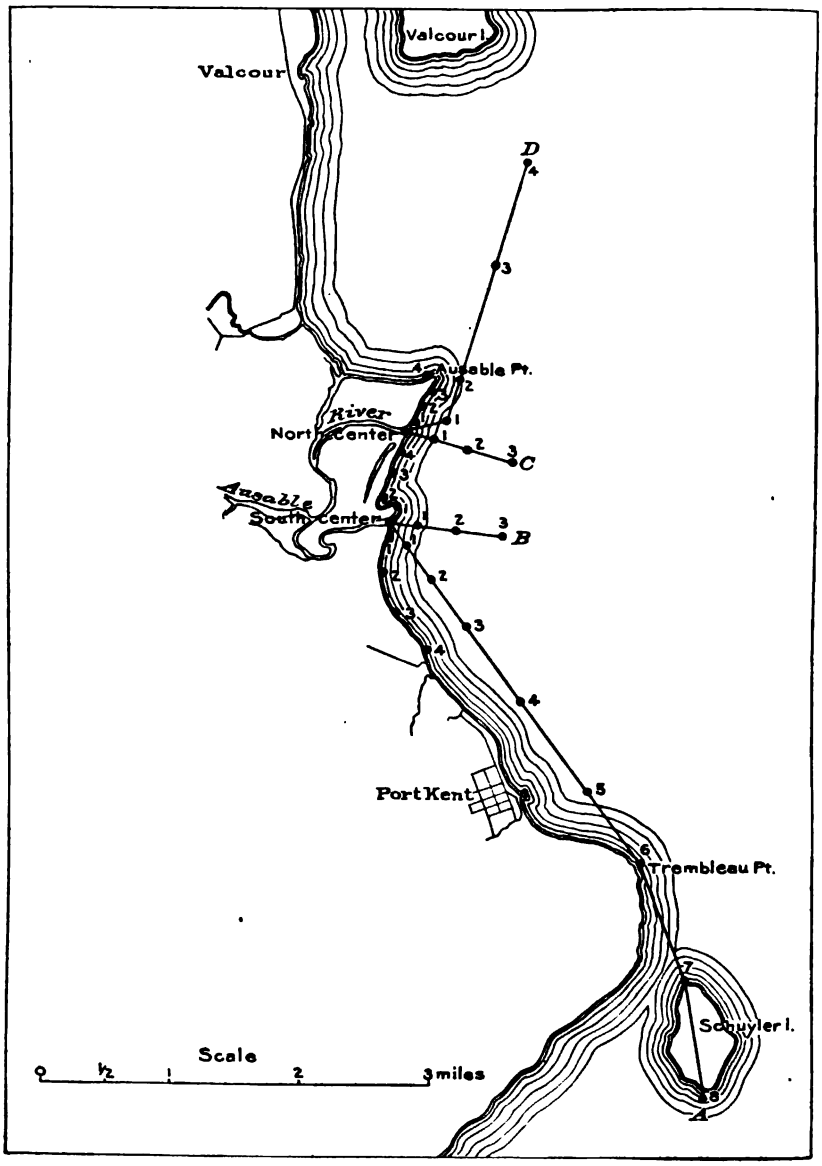


FIG. 1.—Ausable sample series of August 23, 1904.

of 11 miles an hour, reaching a maximum of 21 miles an hour. At the time of sampling, however, this wind had died away and the lake was flat.

Table XII sets forth the results of the determinations made upon the samples. For purposes of comparison the standards set forth in Table III will be restated, as follows: Total solids, 65.6; volatile solids, 21.8; per cent volatile, 32.8; alkalinity, 47. It is readily apparent that a comparison between the actual amount of total solids in each of the samples, as well as the actual amount of volatile solids, does not give as comprehensive information as the statement of the per cent of volatile solids. This, then, is the determining factor so far as solids are concerned.

TABLE XII.—*Ausable sample series of August 23, 1904.*

[Parts per million.]

Sampling point.	Total solids.	Volatile solids.	Per cent volatile.	Alkalinity.
D LINE.				
North center	102.0	64.2	62.7	14.5
D-1	80.8	39.0	48.3	37.0
D-2	66.2	24.8	37.46	44.0
D-3	69.0	33.2	48.12	44.0
D-4	65.0	32.0	49.25	44.0
C LINE.				
North center	102.0	64.2	62.7	14.5
C-1	71.8	34.2	47.35	40.0
C-2	65.4	28.6	43.73	44.0
C-3	68.0	32.6	47.94	44.0
B LINE.				
South center	77.8	43.0	55.27	14.0
B-1	76.0	40.0	52.63	31.0
B-2	64.8	29.2	45.06	44.0
B-3	64.0	28.2	44.06	44.0
A LINE.				
South center	77.8	43.0	55.27	14.0
A-1	78.0	42.6	54.61	20.0
A-2	64.4	28.4	44.09	44.0
A-3	66.0	26.8	40.61	35.0
A-4	67.4	32.0	47.48	38.0
A-5	66.6	29.6	44.44	43.0
A-6	63.8	29.8	46.71	43.5
A-7	64.8	26.8	41.36	44.5
A-8	64.0	29.4	45.94	44.5

TABLE XII.—*Ausable sample series of August 23, 1904*—Continued.

NORTH SHORE.

Sampling point.	Total solids.	Volatile solids.	Per cent volatile.	Alkalinity.
North center	102.0	64.2	62.7	14.5
1	97.6	49.8	51.03	28.0
2	85.6	43.4	51.17	38.0
3	82.0	40.0	48.77	39.5
4	72.6	37.6	51.79	41.5

MID SHORE.

North center	102.0	64.2	62.7	14.5
1	79.6	45.6	57.28	20.5
2	70.4	32.4	44.44	34.0
3	85.0	47.0	55.29	20.5
4	77.0	43.4	56.22	19.0
South center	77.8	43.0	55.27	14.0

SOUTH SHORE.

South center	77.8	43.0	55.27	14.0
1	71.6	38.6	53.91	15.0
2	77.4	37.8	48.84	27.0
3	70.0	33.8	48.29	36.5
4	66.6	29.6	44.4	47.0

Considering now the D line, it will be seen that although the outermost sample was more than 2 miles distant from the river's mouth, the sampling was not carried sufficiently far to reach the point of normal lake water, the farthermost sample taken containing 49.25 per cent of volatile solids and 44 parts per million of alkalinity. The same is true of lines B and C. It is evident from this that the influence of the wastes from Ausable River extends out into the lake for a greater distance than 4,500 feet. The samples taken along the shore are also in excess of the normal per cent of volatile solids. In the farthermost sample of the south shore the alkalinity is normal. The most remarkable line of samples in the series is the A line, in which it is shown that the southward current along the west shore of the lake carries the high amount of solids down beyond the south end of Schuyler Island, a distance of 5⅛ miles, while at that point the alkalinity has not yet been raised to the normal.

Sample series of September 2.—This series of samples was taken under conditions and at points similar to those in the series of August

23 (fig. 2). The D line, running from the north center, was split at buoy 6 east of Ausable Point, one leg running north and another east. The C and B lines were the same as in the previous series, while the A line was the same in direction but marked one less sample on

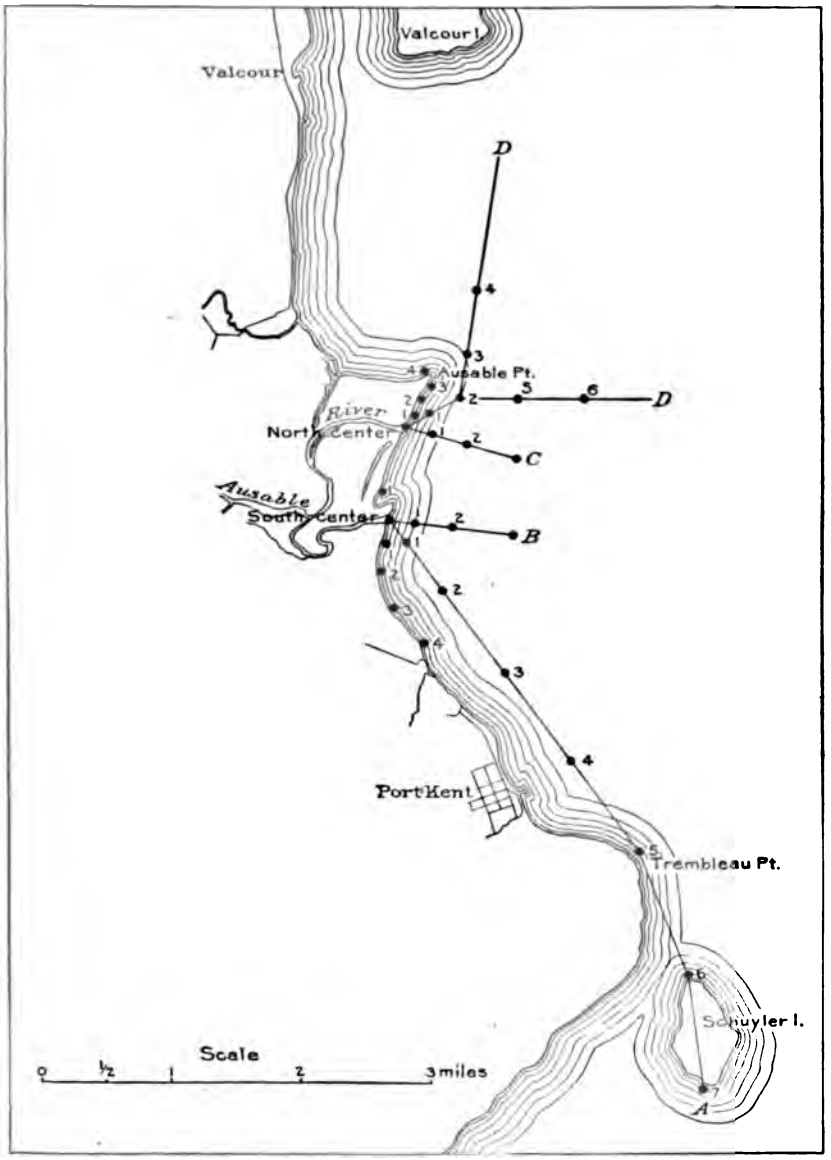


FIG. 2.—Ausable sample series of September 2, 1904.

the stretch between the south center and Trembleau Point. The wind during the twenty-four hours previous to the time of sampling had been blowing lightly from the north, and can hardly be considered an important factor in connection with the results.

TABLE XIII.—*Ausable sample series of September 2, 1904.*

[Parts per million.]

Sampling point.	Total solids.	Volatile solids.	Per cent volatile.	Alkalinity.
D LINE.				
North center	162.2	103.2	63.6	29.5
D–1	64.8	30.0	46.1	43.0
D–2	65.2	32.2	49.4	43.5
D–3	64.8	34.0	52.5	43.0
D–4	70.0	31.6	45.1	44.0
D–5	64.8	30.2	46.6	43.0
D–6	66.8	28.6	42.8	43.0
C LINE.				
North center	162.2	103.2	63.6	29.5
C–1	68.6	34.0	49.6	42.0
C–2	67.4	30.2	44.8	43.0
C–3	68.4	30.6	44.7	44.5
B LINE.				
South center	163.0	106.0	65.0	29.0
B–1	69.0	29.4	42.0	43.5
B–2	68.0	26.8	39.4	44.0
B–3	62.0	26.6	42.9	44.0
A LINE.				
South center	163.0	106.0	65.0	29.0
A–1	66.0	24.4	37.0	43.5
A–2	68.0	28.6	42.1	44.0
A–3	71.4	29.8	41.7	44.0
A–4	73.8	30.4	41.2	44.0
A–5	79.6	34.0	41.7	44.0
A–6	66.6	28.0	42.0	44.5
A–7	68.6	30.0	43.7	45.0
NORTH SHORE.				
North center	162.2	103.2	63.6	29.5
1	107.2	59.4	55.4	36.0
2	68.6	29.4	42.8	42.0
3	87.4	45.4	51.9	40.0
4	97.6	53.2	54.6	36.0

TABLE XIII.—*Ausable sample series of September 2, 1904*—Continued.

MID SHORE.

Sampling point.	Total solids.	Volatile solids.	Per cent volatile.	Alkalinity.
North center	162.2	103.2	63.6	29.5
1	109.2	61.2	56.0	34.0
2	120.0	73.6	61.3	32.5
South center	163.0	106.0	65.0	29.0

SOUTH SHORE.

South center	163.0	106.0	65.0	29.0
1	92.2	50.0	54.2	40.0
2	69.6	32.2	46.3	42.0
3	67.4	32.0	47.5	43.0
4	66.6	31.0	46.5	43.0

It will be seen, on examination of the above series, that the total solids in the water at the north and south centers are extremely large in amount and that from 63 to 65 per cent are volatile. The extremely low alkalinity is also an important factor. Considering first the shore samples, it will be noted that as far as they extend there are unmistakable evidences of pollution from Ausable River. The shore samples taken farthest from the two centers give marked evidence of contamination, and return to normal conditions may not be expected for a considerable distance farther than the outermost sampling points. The course taken by D line of samples, shown in fig. 2, is well directed to illustrate the divergence in the directions along which foreign matter discharged upon the shores of the lake may be felt. Sample 2, on line D, taken at the buoy, shows a percentage of volatile solids of 49.4 and an alkalinity of 43.5. At point 3 there is a slight rise in the percentage of volatile solids and a slight reduction in alkalinity, while at point 4 there is an unmistakable trend toward the normal characteristics of the lake water. How far it would be necessary to pursue this line in order to reach the normal lake is uncertain. Samples 5 and 6, on D line, extending east from point 2 toward the broad lake, show a greater reduction in percentage of volatile solids in the same distance from the center than does the line running to the north.

The results along the B and C lines are similar to those in the previous series. They show simply that at a distance of nearly a mile directly into the lake from the two mouths of the river there is still a marked effect upon the water and that the normal characteristics are not yet recovered.

The A line offers further evidence with reference to the pollution from Ausable River. It will be seen, on examination of the figures, that there is some irregularity in the results of the determination of total and volatile solids and that the reduction in the percentage of volatile solids is not so steady as might be expected. In fact, it is greater 5 miles away from the south center than at a distance of 1,000 feet from it. This is an anomalous result, due undoubtedly to the effects of the wind or local currents which had carried the organic matter along an irregular course on the day previous to that of taking this series of samples. The amount of alkalinity, however, shows a steady increase from the mouth of the river to the end of the A line, and gives in this case the most important testimony concerning the effect of the sulphite waste.

In the two Ausable sample series, reviewed in previous pages, no attempt was made to trace out the limit of influence of the water of Ausable River upon the lake. This was not done because it was believed that if it were shown that the limit of influence is less than a mile the studies subsequently to be made would determine this limit with preciseness, while on the other hand if the matter from the river could be traced for a greater distance it was held that the exact limit was not important, inasmuch as the effect upon the lake would be sufficiently widespread and sufficiently serious to render further investigation unnecessary. The first two series did show, however, that although the samples along the B and C lines did not at the outer points represent the normal lake water, they approached sufficiently near it to show that such a condition might be attained within a reasonable distance. Along the A line, however, it has been shown that the effect of the waste persists for extraordinary distances. The southern trend of the current in the lake along both shores has already been remarked, and the determination of the extreme limit of the effect of the sulphite waste, which in this case is plainly due to the southerly current, is important.

Sample series of September 17.—A series of samples covering the points shown in fig. 3 was determined on and the samples were taken September 17. As will be seen, the central point for this series is taken at a distance of about one-fourth of a mile from the west shore, at a point about midway between the two mouths of the river. From this center the A line extends over practically the same course covered in the two previous series, but is carried on from the south end of Schuyler Island down into Willsboro Bay, to a point opposite Frisbies Point. The B line extends from the center toward Colchester Shoal, a distance of about 1½ miles into the broad lake.

Considering first the results of determinations of the samples taken along the A line, it will be seen that they are somewhat irregular and apparently do not follow the logical trend taken by the samples along

this line in the two previous series. Sample 10, for example, has an alkalinity which is practically normal and presents only a small amount of volatile solids in excess of the observed normal amount for the lake; sample 9, taken well up toward the mouth of the bay, contains practically the same amount of alkalinity, but a considerably larger proportion of volatile solids, while sample 8, opposite the end of Willsboro Point, appears to differ from the normal lake water only in the high proportion of volatile solids. This may also be said of sample 7, which was taken at a distance of nearly 1 mile from the New York shore, well out into the lake and nearly north of Willsboro Point, where a thorough admixture of the waters of the broad lake with any local drainage might be expected. Sample 6, taken south of Schuyler Island in the broad reaches of Corlear Bay, shows results which are nearly normal, while sample 5, taken on the southern shore of Schuyler Island, again indicates considerable organic pollution. Sample 4, taken from the north side, however, indicates a nearly normal water, while sample 3, from Trembleau Point, is again indicative of the sulphite waste from Ausable River. Samples 1 and 2 contain the usual amount of pollution. Sample 2 is lower in its proportion of volatile solids than in the previous series of samples.

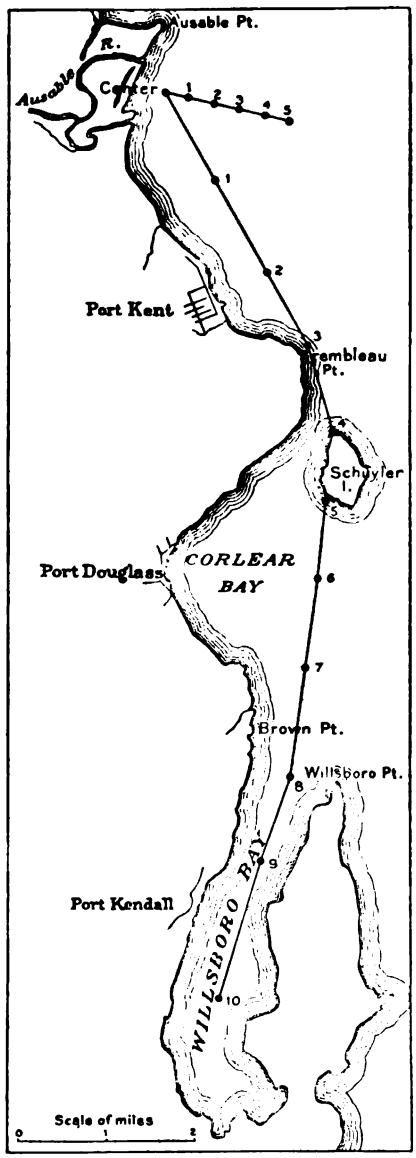


FIG. 3.—Ausable sample series of September 17, 1904.

The B line, which extends into the lake a distance of about 1½ miles, along which were taken five samples, affords results of interest.

It will be seen from these results that the total amount of organic matter in the water was slightly greater in September than in July, and in interpreting the results of the determinations in connection with the Ausable River pollution this should be taken into account.

The determination of alkalinity is absolute, however, and taken in connection with the amount of organic matter as determined by the percentage of volatile solids, is unmistakable. The proper course will therefore be to give little value to the results of the volatile-solids determination, which appear high, but which are not accompanied by a low alkalinity, insisting upon the agreement of the two determinations. Following out this plan, the results of the various investigations with reference to Ausable River are, briefly, as follows:

The effect of sulphite waste from Ausable River in Lake Champlain is apparent north of the river's mouth for a distance greater than 2½ miles, the distance apparently varying according to the prevailing winds. East from the river's mouth into the broad lake the effects are generally appreciable for about 1 mile from the shore, while south from the river the water is certainly affected at times as far south as Willsboro Bay, but usually not farther south than Trembleau Point. The line at which the effect of the river becomes inappreciable in the lake was not determined, for such an investigation would require a large amount of time, covering several seasons at least. From all the indications afforded by the series of samples taken, the line at which the water of the river merges completely into that of the lake is exceedingly irregular, varying according to prevailing winds. It certainly extends considerably farther along the shore, both north and south, than it does eastward into the broad lake.

Having determined that sulphite waste is appreciable for considerable distances into the lake, it becomes necessary to consider what effect this waste may have. As above stated, the waste is composed largely of organic matter, and the effects which it would have must be interpreted according to organic standards. Primarily the character of the organic matter is not harmful to health. It contains no organisms of specific disease, and therefore can not be regarded initially as a menace to the public health. Undoubtedly, however, this organic matter forms a nidus for the development of bacteria in large numbers. Although there was no opportunity to make experiments with reference to the persistence of intestinal bacteria, it is probable, judging from analogous experiments made elsewhere, that such germs would thrive better in water containing this organic matter than in the normal water of the river and lake. So far as a specific disease is concerned, this waste does not do as much initial damage to Ausable River as the sewage which issues from several private sewers in the village of Keeseville. Nevertheless, this does not by any means relieve the

pulp company from responsibility. The measure of damage to the lake by this waste is difficult to determine. The damage to the stream, as has been stated on previous pages, is unquestioned.

There is a certain amount of damage done to the lake, this amount varying according to local conditions. The increased organic matter shown in the above tables is probably responsible for an increased number of bacteria, and there is little doubt that the specific germs of disease would persist longer in this water than in that in other parts of the lake. While it is undoubtedly true that the water of the lake is not so good along the western shore, in the area covered by the investigations, as in the broad lake, the damage is not definite, and it would be impossible to state its actual extent.

In connection with the question of algæ, it has been asserted that this waste is the cause of a more profuse growth than would normally occur along the shores. Certain algæ thrive in water containing a high proportion of organic matter, and the natural inference would be that they would be more abundant in the region under the influence of Ausable pollution than they would if no polluted matter were present. Such abnormal abundance is not discernible, however. There is no greater amount or greater variety of algæ in the lake around the mouth of this river, nor indeed in any part of the lake, than might be expected in an unpolluted body of water.

The pollution from Ausable River discharged into Lake Champlain is by no means cumulative. The conditions as they were found in the series of examinations are without doubt as bad as they ever have been or ever will be. In other words, the organic matter turned into the lake from the river is unstable. It changes from the complex substance to the simple inorganic form and passes out through the lake outlet, diluted so largely with the tremendous volume of purer water as to be unrecognizable.

The waste pulp, an inert cellulose, can of itself exert no harmful effects. It piles up along the shores, makes them unsightly, and undergoes little change. Therefore, while the effect of the pulp waste upon the lake is pronounced and unmistakable, its area of influence is comparatively small and whatever damage may be done does not extend to the entire lake. The damage is therefore more a private than a public one at the present time, and has caused no apparently serious results beyond a limited area.

BURLINGTON AND WINOOSKI RIVER.

SEWAGE POLLUTION.

SOURCES OF SEWAGE AND PLACES OF DISCHARGE.

Burlington, Vt., has, according to the Twelfth Census, a population of 18,640. It is situated on the east side of Lake Champlain, in the center of a broad bay, shown in fig. 4 (p. 77). The water supply of the city is pumped from the lake—the intake being situated northwest of the city at Appletree Shoal—through a suction pipe extending along the bottom of the lake to the pumping station on the lake front, nearly opposite the north end of the harbor breakwater. The sewage of the city is carried by a trunk sewer to the water front and emptied into the lake at the shore nearly due east of the south end of the breakwater (Pl. X, *A*). The outlet is marked by the opening in the timber pier shown in Pl. X, *B*. All sewage except a small, insignificant quantity is discharged through this outlet.

Into the small bay defined by Lone Rock Point and Appletree Point are discharged the wastes of an extensive rendering establishment.

About 2 miles north of Appletree Point, Winooski River empties into the lake (fig. 7, p. 87). This river drains 995 square miles in the State of Vermont, most of it farming or mountain land. Near the upper end of the river is situated the city of Montpelier, and near the mouth are Fort Ethan Allen, an extensive United States Army post, and the village of Winooski, containing 3,783 inhabitants. From both the army post and Winooski village are discharged large quantities of sewage.

The geographic relations of the various points above mentioned to the configuration of the shore are important, as they are such as to protect large areas of water and render them comparatively stagnant; that is, they are so situated that circulation must be considerably less than that in the broad lake. A few miles south of Burlington, Shelburne Bay, a large body of water from 70 to 100 feet in depth, makes into the mainland. Shut in from the rest of the lake except at the comparatively narrow outlet between Shelburne and Red Rock points, this bay is comparatively stagnant. A slight current from the north seems to flow along the shore above Red Rock and circulate in the bay. This is quite pronounced when a strong north or northwest wind is blowing. This bay is therefore considerably polluted by the sewage of Burlington, and on account of the lack of dilution the water reveals a somewhat higher amount of organic matter than has been noted in the water of the broad lake. Burlington is protected by a long, artificial breakwater around which the current swirls, the direction depending largely upon the direction of the prevailing winds. It has been noted by various observers that when the wind blows from the south

A. BURLINGTON, VT., LAKE FRONT.

B. TRUNK SEWER OUTLET, BURLINGTON, VT.

the current seems to be deflected from the lake into the south end of Burlington Bay, thence northward inside the breakwater. Similarly during a northerly wind the subcurrent runs south behind the breakwater. Just north of Burlington there is a small area of comparatively dead water eastward from Lone Rock Point. Between Lone Rock Point and Appletree Point there is another bay well protected except from southerly winds. This is the bay into which the offal from the rendering establishment is turned, and at the mouth of which, on Appletree Shoal, the water intake of the city has been placed. North of this, Winooski River makes out into the lake at a southerly angle, the current deflecting southward even when the lake surface is quiet. Now, as has been stated on previous pages, the normal current of the lake at the shore is southward. The water of Winooski River when discolored by floods is readily traceable southward into the lake, the track having been observed as far south as Juniper Island when strong northerly winds were prevalent.

EFFECT ON LAKE CHAMPLAIN.

The conditions above recited seem to be well adapted for confining the impurities coming from the Burlington sewers and from Winooski River in that immediate region, the trend of the impurities varying with the immediate local conditions. Normally, without winds, the sewage from Burlington takes a southerly turn along the shore of the lake and swings outward, taking a northerly course by Appletree Point, or a little farther to the west. The water of Winooski River apparently flows south and then swirls into the broad lake in the same manner; thus the impurities are concentrated first at one place and then at another, the ultimate mixture giving to the water in the region of Burlington and for several miles north, south, and west a character which by no means warrants its consumption for domestic purposes in the raw state. The impurities issuing from Burlington and the Winooski are almost entirely of a sewage nature, there being very few industries the waste from which complicates the pollution problem in an important degree. The specific tests by which this pollution can be traced are the familiar ones commonly used in sewage-pollution cases. There should be under normal conditions a general increase in the amount of chlorides in the water, a slight rise of the amount of organic matter, but most of all a surplus of intestinal bacteria, of which the *Bacillus coli communis* is the most familiar. Before taking up the consideration of the specific tests which were made in connection with this problem, it will be instructive to review briefly the history of the Burlington water supply and show the effect which the discharge of sewage has had upon it.

EARLIER INVESTIGATIONS.

The facts recited below with reference to the earlier history of the Burlington water supply are condensed from a paper written by Prof. William T. Sedgwick, of the Massachusetts Institute of Technology, entitled "The Sanitary Conditions, Past and Present, of the Water Supply of Burlington, Vt.," which was read before the New England Water Works Association, and printed in the journal of that association, vol. 10, pages 167 to 183, inclusive:

"The Burlington waterworks were constructed in 1867 after considerable discussion and investigation concerning proposed sources. Lake Champlain was finally selected and an intake pipe was established at the northern extremity of the Burlington docks. At first the water gave satisfaction, but from 1871 on there developed considerable uneasiness concerning the dangers arising from the proximity of the water intake and the trunk sewer outlet. The statement generally made in the reports was that while little or no specific water-borne disease had occurred, the condition was a constant menace and might result at any time in a serious epidemic. Suggestions were repeatedly made that the intake pipe should be extended for a considerable distance into the broad lake.

"As years passed intestinal troubles, usually in the form of mild diarrheal disturbances, prevailed, and in the years 1882, 1884, and 1889 typhoid became epidemic. Still, when compared with other cities with undoubtedly pure supplies, the typhoid rate in Burlington was not excessive.

"In 1888 the subject had reached such importance that an investigation relative to the merits of various available supplies was begun. The report of this investigation was published in 1889 in the twenty-fifth annual report of the city of Burlington, pages 95 to 113. This report contained the results of a series of analyses and a discussion of the same by Mr. Joseph L. Hills, chemist of the State agricultural experiment station. In this discussion Mr. Hills stated as follows: 'The station chemists have not been able to detect evidences of sewage in samples from Marks Bay or the pumping station (or indeed in a series of samples taken about 100 yards away from the sewer mouth in the endeavor to trace the direction of sewage currents). * * * One of the most interesting points * * * is that the water from the broad lake does not appear purer than that taken inshore. * * * It does not appear settled that the extension of the suction pipe will of necessity give our community a purer water supply.'"

With reference to the results of this investigation, Mr. F. H. Crandall, superintendent of the waterworks, stated that they (the results) "afford a subject of careful thought and study, as well as a chance for interesting comparisons."

Some of the analytical statements with reference to the water of the lake made in the report above cited are reproduced below in order to show the condition of the water at that time as clearly as the data given admit of interpretation and for purposes of comparison with results of analyses made during the recent investigations.

TABLE XV.—*Chemical analyses of the water supply, etc., of Burlington, Vt., previous to May, 1889.*

Source of sample.	Date.	Analysis by—	Free ammonia.	Albuminoid ammonia.	Total solids.	Volatile solids.	Per cent volatile.	Chlorine.
Mouth of suction pipe, pumping station.	Sept., 1884	Sabin	0.16	0.16	86.0	.....	.....	.....
Do	.....do.....	Witthaus	.052	.13	72.0	.....	.....	2.1
Do	Mar., 1885	.....do.....	.034	.10	89.0	.....	.....	1.1
Do	.....do.....	W. R. Nichols	.02	.15	71.0	14	19.7	.2
Do	.....do.....	Seeley	.....	.....	60.0	19	21.7	.....
Do	Jan. 8, 1889	Hills	.03	.18	88.5	34	38.4	1.7
Northwest corner breakwater, 10 feet deep.	Sept., 1884	Sabin	.06	.114	119.0	.....	.....	.....
Do	.....do.....	Witthaus	.026	.11	84.0	.....	.....	1.5
Do	Mar., 1885	.....do.....	.016	.08	75.0	.....	.....	1.1
Do	.....do.....	W. R. Nichols	Trace.	.08	73.0	13	17.8	2.0
Foot of Bank street	Jan. 8, 1889	Hills	.02	.19	86.0	37	43.0	1.4
Northwest corner breakwater, 26 feet deep.	Sept., 1884	Witthaus	.146	.17	79.0	.....	.....	1.8
Do	Mar., 1885	.....do.....	.34	.08	76.0	.....	.....	1.0
Do	.....do.....	W. R. Nichols	Trace.	.08	70.0	15	21.4	1.8
Marks Bay, 58 feet deep	Sept., 1884	Sabin	.48	.10	107.0	.....	.....	.....
Marks Bay, 62 feet deep	.....do.....	Witthaus	.08	.10	56.0	.....	.....	5.8
Marks Bay	Mar., 1885	.....do.....	.034	.05	66.0	.....	.....	.9
Do	Jan. 8, 1889	Hills	.03	.16	80.0	35	43.7	2.9
Surface, midway sewer mouth to south end breakwater.	Sept., 1884	Sabin	.04	.072	100.0	.....	.....	.....
Do	.....do.....	Witthaus	.08	.13	116.0	.....	.....	9.7
3,000 feet west of pumping station.	Mar., 1885	Seeley	.....	.....	69.0	17	24.6	.....
Rock Point	.....do.....	.....do.....	.....	.....	61.0	17	27.9	.....

"Mild epidemics of diarrhea" continued, with the result that the reassurance established by the report above mentioned gave place to further alarm. The typhoid rate, according to clinical diagnosis of that period, was still sufficiently low to be insignificant. It would be interesting to know how much of this so-called "diarrhea" would, under modern methods of culture diagnosis, be recognized specifically as typhoid fever.

The above statements describe the situation when, in 1892, Professor Sedgwick was invited to make an investigation. In his paper, read some years later before the Water Works Association,[a] he sums up the situation, as it then existed, as follows:

First. It was widely held by physicians and understood by the people that diarrhea was common among users of the water, especially those who had not

[a] Jour. New England Water Works Assoc., vol. 10, No. 3, pp. 167-183.

become habituated to it, visitors to Burlington, if they drank the water, frequently suffering from some diarrheal disturbance.

Second. The location of the intake of the waterworks was less than a mile from the outfall of the main sewer and only a few rods from the docks.

Third. Typhoid fever, the ordinary measure of the sanitary condition of a water supply, was not then, and had seldom been, excessively prevalent in Burlington.

Fourth. Chemical analyses had failed to show any marked superiority in the water of the broad lake (the middle of Lake Champlain) to that at the intake on the shore of Burlington Bay.

Sixth. Investigations had proved that it would be difficult, uncertain, and costly to procure a gravity supply from the mountains, because of their remoteness and for other reasons.

It is only fair to add that at the time of my investigations and of making my report I was less familiar with some of these facts than I am now.

Previous to 1892 the sewer outfall had frequently attracted the attention of physicians and other citizens. When the water in the lake was low the sewage from the main sewer was not discharged into the lake beneath the surface, or even on the lake front, but ran in an open stream over flats laid bare by the receding waters and emptied into a small bay or basin connecting with the lake. The stench which at times arose from this torpid stream, from the flats, and from the bay was highly obnoxious and objectionable, so that a demand had come, especially from the board of health and its efficient health officer, Dr. H. A. Crandall, for an improved outfall. Mr. F. P. Stearns, C. E., engineer in chief of the State board of health of Massachusetts, was finally consulted, and advised an extension of the outfall to the main lake front, with disposal there directly into the lake, and at a depth sufficient to be always below the surface.

I had already been making (in Boston) occasional bacterial analyses of the city water, the water of the lake, etc., for the water commissioners of Burlington, when, on June 20, 1892, I was invited by them to visit the city and make a thorough investigation of the sanitary condition of its public water supply, present and prospective. I did as I was desired and subsequently presented a report, of which the following is the principal portion:

BOSTON, *June 30, 1892.*

The BOARD OF WATER COMMISSIONERS,
Burlington, Vt.

GENTLEMEN: I have the honor to submit to you a report upon my investigations, made at your request, concerning the sanitary condition of the Burlington water supply and the probable sanitary effect of certain proposed changes therein.

I am informed that many of the physicians regard the water supply with suspicion, and I find that the successive health officers in their official reports have frequently referred to the water as more or less objectionable. I therefore undertook, first, to discover the actual effects of the water supply upon the health of the city.

In order to do this in the case of a water supply suspected of sewage contamination it is customary to take as a measure the prevalence of diarrheal diseases and especially typhoid fever. I have therefore carefully studied the vital statistics of Burlington for the last twelve years, comparing the mortility from typhoid fever with the total mortality and also with the number of inhabitants.

The results show conclusively that the mortality from typhoid fever (and the same is true for diarrhea and dysentery) has not been large in Burlington during the last twelve years. The average annual mortality from typhoid fever from 1870 to 1891 in Burlington was 3.57 per 10,000 inhabitants.

I then went on to show that Burlington compared favorably in this respect with many cities having water supplies of undoubted purity, and stated that in respect to mortality from typhoid fever it had a better record than "many cities having water

supplies of good reputation." This weighty fact alone justifies the conclusion that there is no positive evidence in the sanitary statistics of the city that the water supply is injurious to public health. I may add by way of confirmation that during the last three years I have made repeatedly bacteriological analysis of the Burlington supply, and that I have found no satisfactory evidence of the presence of sewage in the drinking water.

It is interesting and instructive to compare the history of typhoid fever in Burlington during the last six years with that during the earlier half of the period under consideration, for in this way we may learn whether this disease is or is not increasing. If we do this we obtain the following results:

Statistics of typhoid fever in Burlington, Vt.

	Six-year periods.	
	1880–1885.	1886–1891.
Average annual death rate from typhoid fever per 10,000 inhabitants	3.39	3.75
Average annual mortality percentage from typhoid fever	1.73	1.83

These figures are certainly reassuring, and prove conclusively that there is no immediate reason for excessive anxiety or alarm for the sanitary condition of the water supply.

It is, however, the opinion of many Burlington physicians, based upon their experience, that the water supply is responsible for the occurrence from time to time of diarrheal disturbances which, while they very rarely result in death, serve to annoy and alarm the citizens. In the present state of our knowledge it is at present impossible to prove or to disprove this theory. The fact appears to be that such disturbances are common, and it is well known that the main sewer of the city empties into Lake Champlain, the source of the water supply, less than a mile from the intake. Whether there is anything more than coincidence in these facts it is impossible to say. In the present state of sanitary science, however, there can be no doubt whatever that the location of the intake of the waterworks, as near as it now is to the main sewer of the city, is highly objectionable, if not positively dangerous. I can only regard it as a constant menace to the sanitary welfare of the city. It must be admitted as entirely possible that unpurified sewage driven by winds or carried by currents may be in the future, if it has not been in the past, conveyed more or less directly from the sewer outfall to the water intake.

I have, therefore, at your request, considered the probable sanitary advantages of a removal of the intake of the waterworks to a point in the "broad lake" some 3 miles from its present position, and also those of a complete change from the lake to a mountain supply.

In regard to the former—the broad-lake supply—I am of the opinion that it would be of very great advantage from a sanitary standpoint, inasmuch as it would so far remove the intake from the sewer outfall as to make it unlikely that raw sewage would ever pass from the latter to the former, while at the same time it would give more time for the purification en route of any sewage which might accidentally so pass. Unless the city should become very much larger than it now is, the passage of sewage from the sewer outfall to an intake located, for example, on Appletree Reef, through the present sewer basin and the quiet waters of the bay, can only be regarded as a remote possibility.

I may remark in passing that, in my judgment, one reason for the comparative immunity from epidemics of typhoid fever hitherto enjoyed by this city is that the sewage is held in a small bay for a longer or shorter time, according to circumstances, where it can to some extent become freed from the germs of disease.

If Burlington could draw its water supply by gravity from mountain streams or storage reservoirs and secure abundant water from an unpolluted watershed the danger of infection of the water supply would be done away. So far as I can judge, however, there are no streams of sufficient size and purity directly available. Storage would be an unavoidable necessity. But storage, while of great sanitary advantage so far as the germs of specific diseases are concerned, is apt to lead to disagreeable consequences in other directions. The water drawn from storage reservoirs is often more or less colored by peat, stumps, leaves, etc., and not infrequently suffers fermentation with the development of organisms, acquiring thereby disagreeable and sometimes nauseous tastes and odors. If these compel the citizens to abandon its use and lead them to resort to polluted wells or other objectionable sources of supply, the sanitary consequences may be unfortunate. It will be seen, therefore, that, while a mountain supply is in many respects highly desirable, it is nevertheless true that its adoption in this case would be attended with the possibility of some undesirable consequences. It must be remembered that every new water supply depending upon the storage of surface water is an experiment. It can not be undertaken without some risk of undesirable results.

In fine, I am of the opinion that there is no positive evidence of any injurious characteristics in the present supply. But I believe nevertheless that in view of the common occurrence of diarrheal disturbances reported by physicians, and on account of the menace to the public health involved in the present arrangement, some other source of supply should be found. I think that it would be of very great sanitary advantage to remove the intake as far as possible out into the broad lake. A mountain supply in storage reservoirs would afford complete relief from sewage or contamination, but might involve serious troubles with microscopical organisms, tastes, and odors.

Respectfully submitted. WILLIAM T. SEDGWICK.

This report was generally accepted as establishing the fact that, while there was no occasion for immediate alarm or excessive anxiety, it was imperative that steps should be taken as soon as practicable to improve the situation. The epidemics of 1882, 1884, and 1889 were not forgotten, and the figures submitted by me showed a perceptible, though slight, increase of typhoid fever and diarrheal disturbance during the more recent six-year period. Accordingly, after still further deliberation, it was decided to extend the intake pipe some 3 miles from the sewer outfall into the lake, to a point known as Appletree Reef, which had been found by repeated bacterial analyses to be a favorable one for the purpose. This extension, as has been fully described in the preceding paper by Mr. Crandall, was made in the summer of 1894. Its completion was undoubtedly hastened by the improved sewerage plan recommended by Mr. Stearns in 1892, and about to be carried out by the sewer commissioners, by virtue of which the main sewer outfall would be pushed outward to the lake front and the sewage discharged at all seasons beneath the surface of the lake. As soon as this improvement became assured, Mr. Crandall and the water commissioners, as well as the board of health, redoubled their activity in urging that the intake of the water supply should be moved farther out into the lake, and all the more because the little bay in which at certain seasons the sewage fermented and doubtless worked itself to some extent free from disease germs was now to be obliterated, so that fresh sewage might at times readily find access to the currents, if any, along the lake front at a point less than a mile from the intake of the waterworks.

I have lately had made by an assistant—Mr. S. C. Prescott, in the laboratory of the Vermont agricultural experiment station, kindly placed at our disposal by Professor

Jones, to whom our hearty thanks are due—a series of careful bacterial analyses of water taken from various points on the high service and the low; at the pumping station; from the pump well, and from the lake just outside, a point which corresponds to the old intake; from the lake front near the sewer outfall, and from the new intake on Appletree Reef. These show conclusively, both by comparison with analyses made before the extension of the intake and by comparison one with another, that the removal of the intake to a distant point in the lake has caused a marked bacterial improvement in the purity of the city water.

In discussing the results of the biological investigations made in connection with his examination, Professor Sedgwick demonstrated by actual plate cultures of equal amounts of water from different parts of the lake the progressive disappearance of bacteria from the sewer outlet, where they abounded, to the old intake, where they were relatively few yet far more numerous than at the new intake or at any point in the service pipes. In connection with this he submitted sanitary analyses showing the amounts of organic matter at the old intake of the lake and in the city water after the intake was extended to Appletree Reef, and the condition of that organic matter, as follows:

TABLE XVI.—*Sanitary analyses of water of Lake Champlain at new and old intakes.*

	Lake (old intake).	Tap (city service).
Total solids	66.00	62.00
Volatile solids	12.5	10.5
Per cent volatile	19.00	16.9
Albuminoid ammonia	.138	.120
Free ammonia	.01	.00
Nitrites	.00	.00
Nitrates	.01	.10
Oxygen consumed	2.730	2.496
Chlorine	1.40	1.00
Hardness	42.00	42.00
Iron	.06	.06
Microscopical organisms in 100 cubic centimeters:		
Diatoms	3,550	1,050
Algæ	1,400	6,200
Blue-green algæ	200	150

In discussing the improvements brought about by the extension of the intake pipe into the lake, Professor Sedgwick reported as follows:

But there is yet another kind of evidence which witnesses still more eloquently to the improvement of the water supply. This is the testimony of the physicians of Burlington. As far as I have been able to communicate with them—and I have interviewed a number of the most prominent and representative—there is a surprising and remarkable unanimity of opinion among the local physicians to the effect that

the peculiar diarrheal disturbances which had so long prevailed in Burlington have, since the extension of the intake pipe, wholly ceased; and the physicians are enthusiastic in their recognition of the salutary change, which they attribute entirely to the improved water supply.

In view of all the evidence at hand—statistical, bacteriological, chemical, and medical—I think we may safely conclude that the sanitary condition of the water supply of Burlington is now most excellent. If, however, in the future Burlington grows extensively and becomes a much larger city it will probably become necessary here, as in most large cities, to face once more the question of a pure water supply. Special pains must also be taken to see to it that the intake pipe is kept intact and free from leakage. The unfortunate experiences of Toronto and Buffalo with broken intake pipes afford ample warnings in this direction.

This is the first case within my own experience, now somewhat extensive, in which epidemic diarrhea in a mild form has prevailed in a community for many years, having its etiology in the consumption of impure water, as has been proved by its apparent total disappearance on a change in the source of supply. The importance of the case in the history of water-borne diseases is manifest. It was complicated by the fact that typhoid fever, which is usually taken as a measure of the sanitary condition of the community, was here ordinarily by no means excessive, and that its occasional prevalence might easily have been due to some other cause than polluted water. The fact seems to be, however, that it was in truth really due to impure water, inasmuch as since the extension of the intake pipe in 1894 typhoid fever has practically disappeared. If would seem fair to conclude, from the moderate occurrence of typhoid fever, while diarrhea abounded, that germs of the latter disease, more hardy than those of the former, were frequently able to survive a journey from the sewer outfall to the water intake, while those of typhoid fever, if present, usually perished. In future sanitarians will not be able, by the test of typhoid fever alone, to show that a water supply is above suspicion. A mild form of diarrhea caused by polluted water may apparently prevail even in the absence of any constant or considerable excess of typhoid fever.

PRESENT CONDITIONS.

The statements above recited with reference to the water supply of Burlington indicate in a measure the condition of the lake in front of the city twelve years previous to the investigation of which this publication is a report. Since that time the population of Burlington has increased about 30 per cent. Therefore, the conditions, admittedly bad during that period, must of necessity be still more unfavorable at the present time. It is therefore safe to enter upon the investigation with the assumption that Burlington sewage does damage the lake, and the problem resolves itself into a question of the extent of that damage.

One of the most striking features in connection with Burlington pollution brought out by the report of Professor Sedgwick is the apparently enormous power possessed by the lake to assimilate large quantities of contaminating matter and to conceal almost every chemical as well as biological evidence of the presence of pollution. It is inevitable that the increased quantity of sewage resulting from the increase in population above stated will render the detection thereof in the lake

a less difficult matter than during the period covered by Professor Sedgwick's report. In addition to this, the interesting question presents itself, whether or not by the continued pollution, year after year, the lake immediately surrounding has lost a part of the remarkable power which it was at that time shown to possess of assimilating these impurities and making their detection difficult. Undoubtedly precipitation of the organic matter is a great feature of this so-called assimilating power, and it has been well shown that the continued sedimentation of putrescible matter will in time result in such large accumulations that the actual conditions will assume those somewhat similar to a septic tank. In other words, the area will become a seat of fermentative changes, the result being that the character of the surrounding water reveals these conditions and a large part of the power to conceal sewage is lost. No opportunity was afforded to investigate with reference to this particular point, but the results hereinafter submitted contain interesting suggestions with reference to it.

Burlington sample series of September 16.—The first samples taken to determine the extent of Burlington pollution were from along the shore of the lake, south of the city and continuing around the shores of Shelburne Bay. This course is indicated in fig. 4 (p. 77), showing sampling points 1 to 19, beginning a few rods south of the southernmost end of the Burlington breakwater and, after circling around the bay, ending a short distance east of Shelburne Point. The determinations made with these samples consisted of (1) total solids on evaporation, (2) loss on ignition, (3) per cent loss on ignition, and (4) chlorine. No biological samples were taken in this series, as the principal object was to determine whether or not intelligent results could be secured by chemical means only. It was well understood that with the normal conditions of current southward the water of the lake off the shore from Red Rock Point to Burlington Harbor would be distinctly polluted with sewage. The results of the determinations in this series of samples are set forth in Table XVII.

TABLE XVII.—*Burlington pollution sample series of September 16, 1904.*

Sampling point.	Total solids.	Volatile solids.	Per cent volatile.	Chlorine.
1	60.0	24.0	40.0	1.4
2	60.0	25.0	41.7	1.4
3	71.2	22.4	31.4	1.4
4	49.2	18.0	36.9	1.1
5	66.4	26.4	39.8	1.1
6	72.0	28.0	39.0	1.5
7	60.0	23.2	38.7	1.0
8	61.6	19.2	31.2	1.2
9	84.0	32.8	39.0	1.0
10	77.4	33.6	43.4	1.3
11	56.8	19.2	33.8	1.3
12	59.2	27.2	57.8	1.4
13	68.0	31.2	45.9	1.5
14	65.2	27.2	41.7	1.0
15	66.8	27.6	41.3	1.0
16	64.8	31.2	48.1	1.1
17	64.8	24.8	38.3	1.4
18	69.6	30.4	43.7	1.1
19	64.0	27.2	42.5	1.3

Although the results set forth in the above table indicate unmistakably the polluted condition of the water in the region in which the samples were taken, there appears to be no continuity nor general logical trend as the distance from the polluting point is increased or diminished. The results also emphasize the fact that although a large amount of sewage matter is turned into the lake at Burlington the determination of volatile solids does not set forth the conditions clearly. This determination is therefore unworthy of confidence except in those cases where the accompanying determinations agree relatively with them. A few of the samples, such as Nos. 10, 12, 13, and 16, show a percentage of volatile solids considerably higher than the normal for the lake, and it will be noted that the chlorine in those samples is abnormally high. On the other hand, the results of the determination in sample 6 show a normal amount of volatile solids with extraordinarily high chlorine. As might be expected, the chlorine determinations give the specific results valuable in the investigation. It will be seen that by far the greater majority of the samples contained an amount of chlorine considerably higher than the normal. This can be due to nothing else than the Burlington sewage. On the other hand, there were several samples containing a

normal amount of chlorine, which may be explained by the statement that the dilution by the purer water from the broad lake must be irregular in the bay, as in fact the physical conditions would indicate.

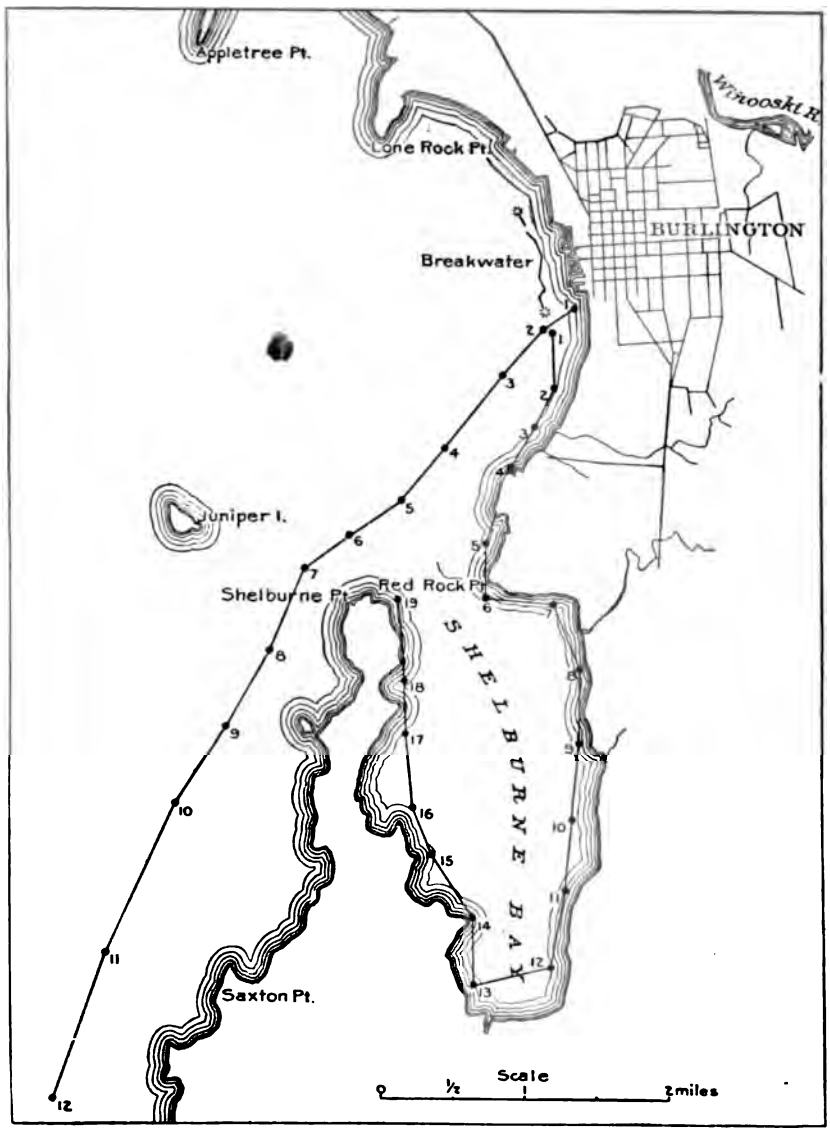


FIG. 4.—Burlington sample series of September 16 and 17.

Burlington sample series of September 17, 1904.—A second series of samples involving similar determinations was taken on September 17, the course running south from Burlington along the shore for 7 miles to a point a short distance north of Quaker Smith Reef. This series consisted of 12 samples distributed along the line shown in fig. 4. The

following are the results of the determinations made upon these samples:

TABLE XVIII.—*Burlington pollution sample series of September 17, 1904.*

Sampling point.	Total solids.	Volatile solids.	Per cent volatile.	Chlorine.
1	66.0	24.0	36.4	1.2
2	53.6	20.4	38.1	1.3
3	66.8	28.8	43.1	1.2
4	62.4	24.8	39.7	1.1
5	61.6	24.0	38.9	1.1
6	60.8	17.6	29.0	1.1
7	65.6	25.2	38.4	1.0
8	66.8	22.8	34.1	1.2
9	79.6	24.0	30.2	1.3
10	74.8	32.0	42.8	.9
11	63.2	27.2	43.0	.9
12	70.0	30.0	42.8	1.0

The series of samples set forth in the above table affords results of little practical value save to show that at the lower end of the line, in the region of Quaker Smith Reef, the water is normal. There is no increase in per cent of volatile solids commensurate with the conditions as they might be supposed to exist in those stations, and in connection with the series of September 16 the conclusion must be drawn that the determination of volatile solids is without value in connection with this investigation. The amount of organic matter imparted to the lake is immediately diluted to so large an extent that the relative variations in the diluted sewage are not sufficient to account for any important amount of variation in the character of the water from the mouth of the sewer out into the lake. It is true that in a broad sense the relative amounts of chlorine give results which indicate something of importance, but as specific determinations for the tracing of sewage in this region it must be admitted that they are exceptionally weak.

While the two previous series of samples show unmistakably that the water to the south of Burlington is polluted by sewage, there is not sufficient definition in the results to indicate even approximately the extent to which the sewage may be harmful in the lake.

Sample series of September 22, No. 1.—In the next series of samples, taken on September 22, it was determined to try the results of complete sanitary analyses, in order to show whether the evidence

with reference to the amount and condition of the organic matter would afford any better indication of sewage contamination than did the determination of volatile solids and chlorine. The samples were taken mainly inside the breakwater and along a line extending to the

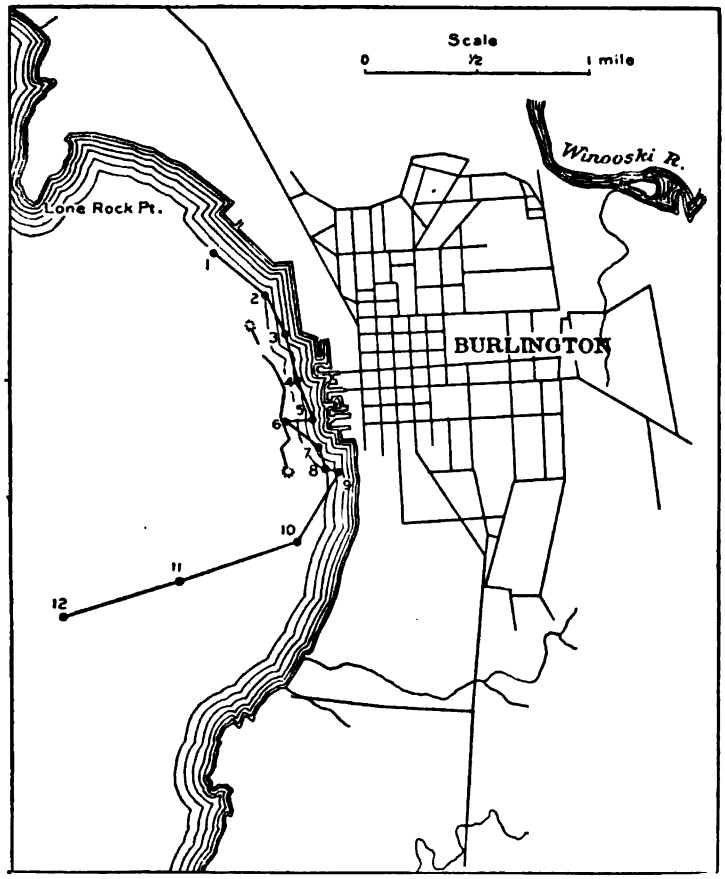


FIG. 5.—Burlington sample series of September 22, No. 1.

southwest, the direction thereof following that which was believed to be taken by the sewage from the outlet at Burlington (see fig. 5).

The results of the analyses, together with the determination of the number of bacteria and the presence of *Bacillus coli communis*, are included in Table XIX.

TABLE XIX.—*Sanitary analyses in sample series of September 22, No. 1.*

[Parts per million.]

Sample.	Turbidity.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Volatile solids.	Per cent volatile.	Hardness.	Bacteria.	*B. coli communis.*
				Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.							
1	Distinct...	15	1 V.	0.132	0.006	0.000	0.160	1.0	69.0	17.0	24.6	51.4	400	+
2	.....do....	15	1 E.	.128	.014	.000	.180	1.0	71.0	20.0	28.2	51.4	640	+
3	.....do....	13	1 V.	.116	.004	.000	.170	.9	68.5	19.0	27.7	50.0	200	+
4	.....do....	13	1 E.	.112	.002	.000	.160	.9	71.5	19.5	27.0	51.4	640	+
5	.....do....	13	2 A.	.120	.006	.000	.170	.9	69.5	19.5	28.1	50.0	300	+
6	.....do....	15	1 A.	.204	.016	.000	.190	.9	72.0	20.0	27.6	51.4	610	-
7	.....do....	8	2 A.	.106	.002	.000	.160	.9	66.5	16.0	24.1	50.0	300	-
8	.....do....	8	1 A.	.142	.026	.000	.160	.9	66.5	13.5	20.3	51.4	680	+
9	.....do....	13	1 A.	.130	.012	.000	.160	.9	69.0	20.0	29.0	48.6	780	+
10	.....do....	8	1 A.	.186	.008	.000	.170	.8	72.0	22.0	30.6	50.0	500	+
11	.....do....	14	1 A.	.138	.008	.000	.170	.9	69.5	20.5	29.5	48.6	920	+
12	.....do....	9	1 A.	.134	.014	.000	.170	.9	71.0	20.0	28.2	51.4	680	+

In considering the results set forth in Table XIX it will be of interest first to compare, so far as the material admits of comparison, the conditions existing in the water at the present time with those indicated in previous pages, Tables XV and XVI. It will be noted that in Table XV certain determinations were given with reference to the water from the lake at the mouth of the suction pipe, as then situated at the northern extremity of the Burlington docks. With the first 6 determinations a fair comparison can be made with the results of sample 2, Table XIX. The sample was taken a short distance west of the dock at which the intake pipe was formerly situated. It will be seen at once that the amounts of free and albuminoid ammonia expressed in both tables are not materially different. Some of the determinations in the earlier series show greater amounts of these two constituents than were shown in sample 2 in the table above. Therefore these two determinations can not be accepted as indicative of any comparative amounts of pollution.

In the fifth and sixth determinations of the earlier series it will be noted that the amounts of total solids are not materially different, but the analysis of September, 1904, shows a considerable increase in volatile material over the determination made by Seeley in March, 1885. This relative difference disappears, however, when the determination of Hills, made January 8, 1889, is taken into consideration. The per cent of volatile solids, therefore, does not indicate an absolute increase in the amount of organic matter. Indeed, the determinations here considered are not well fitted to show the facts desired. The amount of organic matter varies from day to day, and these fluctua-

tions are sufficient to vitiate any intelligent interpretations. There should be a large number, covering a considerable season, to afford a general survey or average which will be largely representative of actual conditions.

The amounts of chlorine set forth in the various determinations here compared offer no better information than do the determinations of organic matter. The two determinations which are of value in this work are those of *Bacillus coli communis* and the number of bacteria per cubic centimeter. This determination does not appear in the earlier analyses, but in those of September, 1904, it is shown that the number of bacteria is large and that there is undoubted indication of intestinal pollution.

The determinations made by Sabin and by Witthaus in September, 1884, of samples taken from the surface midway between the sewer mouth and the south end of the breakwater, may be fairly compared with samples 7 and 8 in Table XIX. The only information recorded in the earlier determinations is that with reference to total and volatile solids, free and albuminoid ammonia, and chlorine. The total solids in the later determinations, as well as the chlorine, are considerably lower than those made in 1884. The amount of chlorine in the determination made by Witthaus is enormous, while the amount of total solids in both of the earlier samples is sufficiently high to confirm the chlorine determination. On the other hand, it is shown that the chlorine in the water taken during the recent investigation is below that determined as the normal for the broad lake. The determination is certainly anomalous, is not borne out by the facts known to exist, and is unworthy of confidence. To offset this the bacteriological determinations show clearly the presence of *Bacillus coli communis*, and, in the case of sample 8, of a high number of bacteria per cubic centimeter.

Comparing the analysis of sample 2 in Table XIX with that of the lake water at the old intake, in Table XVI, it will be seen that while the total solids in the later sample are considerably higher than those in the earlier, the amount of volatile matter is 60 per cent greater. The amounts of free and albuminoid ammonia are not significant in this comparison. While the nitrates are considerably higher in the later determination, chlorine is found to be somewhat lower in Table XVI. On the whole the comparison assists very little in arriving at any decision with reference to the amount of pollution in the lake at the dates of the determinations. Throughout the entire period of investigation, from 1889 to the present time, chemical evidence in relation to the effect of Burlington sewage upon Lake Champlain is of little value, and in many respects is misleading to a dangerous degree.

It will now be in order to contrast the determinations recorded in the above table with those which were made with the sample series of Sep-

tember 16 and 17, and to show, if possible, whether the additional data contained in the later series with reference to the amount and condition of organic matter give any more evidence concerning the pollution of the lake than do the determinations of total and volatile solids, which were found to be of practically no value in the earlier series.

In the foregoing discussion of the results of September, 1904, compared with those taken from 1885 to 1892, it was shown that there is no significant difference in the various determinations, and that in both series of samples the chemical evidence was of no value in determining the actual effect of Burlington sewage on the lake. A little consideration will result in the same conclusions with reference to the series set forth in Table XIX. There is no logical variation in the amount of albuminoid ammonia, the sample taken directly in front of the sewer outlet showing not as much organic matter in any of the various forms determined as that taken at more distant points, where the effects of pollution must necessarily be less. So far as the general evidence contained in the table goes, it throws no light upon the problem in hand, and the entire interpretation must be based upon the number of bacteria per cubic centimeter and the presence of intestinal bacteria. The following is a statement by Dr. B. H. Stone, director of the State laboratory of hygiene at Burlington, Vt., who conducted the biological investigations with reference to the methods employed to isolate the *Bacillus coli communis*.

(*a*) A fermentation tube filled with a 2 per cent faintly acid lactose bouillon, to which has been added 1 per cent of one-half of 1 per cent aqueous solution of neutral red, is inoculated with 5 cubic centimeters of the water to be examined, or 5 tubes are inoculated with 1 cubic centimeter each. If no gas is found after an incubation period of twenty-four hours at 37° C. the absence of the colon bacillus is shown.

(*b*) If from 25 to 70 per cent of gas is formed in the closed arm, a tube containing 10 cubic centimeters of neutral broth, to which has been added 0.3 cubic centimeter of Parietti's solution, is inoculated with one-half cubic centimeter of the contents of (*a*) and incubated twenty-four hours at 37° C.

(*c*) A second fermentation tube is now inoculated with one-half cubic centimeter of the contents of (*b*) and grown twenty-five hours at 37° C. If there is no gas we may be sure the gas producer in (*a*) was not the colon bacillus. If, on the other hand, 25 to 70 per cent of gas is produced in this tube with the characteristic neutral red yellow-red reaction (the fluid in the open arm remaining red while the closed arm shows a beautiful fluorescent yellow with a sharp line of demarcation between—Stokes) we may be reasonably sure that the colon bacillus is present.

(*d*) Further confirmation is obtained by ascertaining the gas formula from (*c*). The formula for the colon bacillus is $H:CO_2=2:1$.

The tests for *Bacillus coli communis* noted in the foregoing statement were presumptive, and under ordinary conditions could in no wise be accepted as conclusive evidence of the presence of that organism. In the interpretation of results there must arise a question as to the value of presumptive tests. The general opinion among water bacteriologists is that such tests may indicate this organism, but that

it is necessary to resort to additional methods of identification where there is any doubt with reference to the presence of sewage. It should be remembered, however, that in the present case presumptive tests were made in water in which the presence of sewage had been clearly established. In justifying their use it must be admitted that the question of presence of the sewage organism is not involved. The large volumes of sewage pouring into the lake from the trunk sewer settle the question so far as mere presence of *Bacillus coli* is concerned. Years of research have demonstrated that this organism must be present under such conditions. The problem, then, is merely to determine the area of influence of these organisms. Numerous presumptive tests made upon the water of the broad lake failed to give positive results in a single instance; therefore, taking into consideration the fact of negative evidence in the broad lake and positive evidence in the area known to be polluted, the presumptive tests are undoubtedly safe and certain in tracing the extent of sewage pollution.

Considering only the bacteriological evidence set forth in the results in Table XIX, it will be noted that throughout the course covered by the series the number of bacteria per cubic centimeter is large and that the presence of the colon group indicates undoubted evidence of intestinal bacteria. At sampling point No. 12, situated at a distance of about 2 miles from the outlet sewer, in a southwesterly direction, the number of bacteria is extremely high considering the distance, and the *Bacillus coli communis* still persists.

It has been shown by the series of September 16 that south of the city and in Shelburne Bay there are undoubted evidences of pollution. The series of September 17 indicates that this pollution does not extend as far south in the lake proper as Quaker Smith Reef. The series of September 22, the results of which are set forth in Table XIX, show conclusively that the inner harbor of Burlington is polluted and that the condition can be traced for a considerable distance to the southwest in a broad, sweeping curve, following the course which, from various observations, was determined to be one of those followed by the Burlington sewage.

Sample series of September 22, Nos. 2 and 3.—On the same day, September 22, two other series of samples were taken (fig. 6). The first extended from the foot of Maple street past the outlet sewer, turning around the south end of the breakwater in a sharp curve, and extending northward toward Appletree Point for a distance about equal to the length of the breakwater. The second extended from the shore opposite the railroad depot along a straight line, passing close to the north end of the breakwater and thence to Lone Rock Point. The object of these samples was to show to how great an extent northwestward from the city the intestinal bacteria might be traced, and especially to determine whether the regions immediately outside the breakwater were affected.

The result of the first series set forth in Table XX refer to the samples taken along the course extending from Maple Tree dock to point No. 7, opposite the rift in the breakwater, as shown in fig. 6.

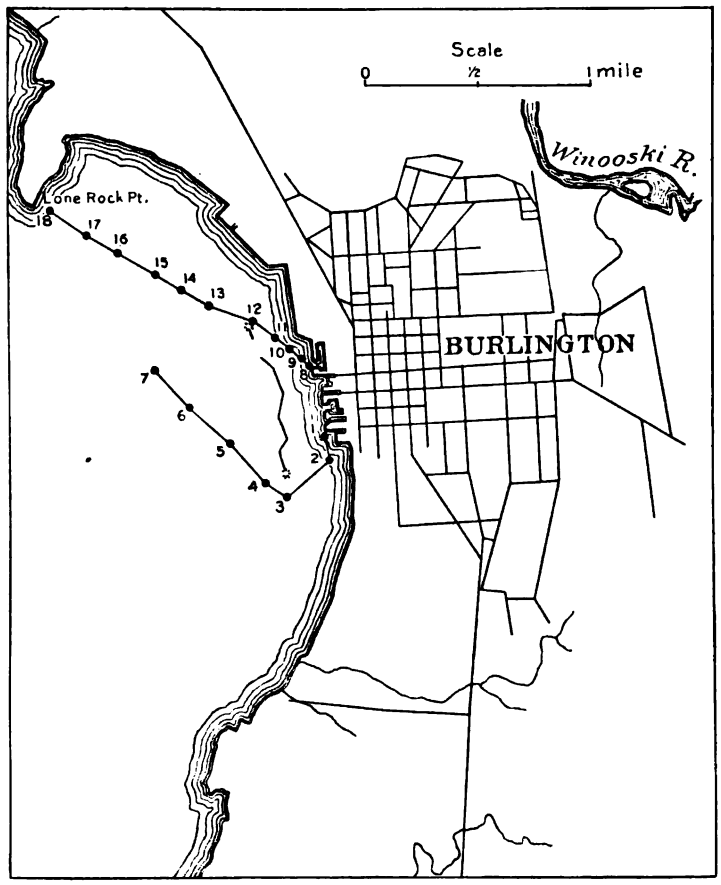


FIG. 6.—Burlington sample series of September 22, Nos. 2 and 3.

TABLE XX.—*Burlington sewage sample series of November 22, 1904, No. 2.*

Sampling point.	Chlorine.	Bacteria per cubic centimeter.	B. coli communis.
1	1.1	250	Present.
2	1.4	300	Do.
3	1.4	300	Do.
4	1.3	550	Do.
5	1.3	300	Do.
6	1.1	250	Do.
7	1.0	300	Do.

The results of this series show a general contamination along the course upon which the samples were located. The amount of chlorine is abnormally high at the sampling points inside and to the south of the breakwater, while at points 6 and 7 evidence of pollution disappears, so far as the chlorine is concerned. The number of bacteria, too, upon comparison with the preceding series, shows that the water close outside the breakwater contains less organic matter than that in series No. 1 for September 22. This indicates that the greater part of the sewage takes a broader sweep to the south and west than the course followed in this series. The fact that intestinal bacteria were present in all samples is, however, the best evidence concerning the condition of the lake. Sewage pollution is undoubtedly present.

The third series of samples, extending northwestward from the city to Lone Rock Point, gave the following results:

TABLE XXI.—*Burlington sewage sample series of September 22, 1904, No. 3.*

Sampling point.	Chlorine.	Bacteria per cubic centimeter.	B. coli communis.
8	1.4	250	Present.
9	1.3	150	Do.
10	1.3	150	Do.
11	1.4	250	Do.
12	1.4	100	Do.
13	1.1	100	Do.
14	1.3	100	Do.
15	1.0	50	Do.
16	1.1	150	Do.
17	1.2	100	Do.
18	1.3	100	Do.

The amount of chlorine in the samples examined in this series shows a generally polluted condition along the entire course; while the number of bacteria per cubic centimeter is not significant, the presence of colon bacteria in all samples repeats the testimony given in the first and second sample series.

Burlington and Winooski sample series of September 25, 1904.—The next and final series of samples taken with reference to the sewage of Burlington also included observations concerning the effect of Winooski River. Before taking up the series, however, a few observations must be made concerning Winooski River above Fort Ethan Allen and below the village of Winooski. In Table XXII are the results of sanitary analyses of the water from both of these points. The data show conclusively that the river above the fort still retains the evidences of pollution which it has received at its source. This evidence is not con-

tained in the determination of the amount and condition of organic matter, but is plainly shown in the results of the bacteriological examination. Six hundred bacteria per cubic centimeter is probably somewhat higher than should be present in the river, while the presence of the colon bacillus gives undoubted evidence of intestinal pollution. The sample taken below Winooski shows an undoubted increase in the number of bacteria, colon being again present. It is but a short distance from Winooski to the mouth of the river, and the water discharged into the lake is without doubt in a condition represented by the second analytical statement in the table.

TABLE XXII.—*Sanitary analyses of Winooski River water above Fort Ethan Allen and below Winooski village.*

[Parts per million.]

Source of sample.	Turbidity.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Volatile solids.	Per cent volatile.	Hardness.	Bacteria.
				Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.						
Winooski River above Fort Ethan Allen.[a]	Distinct ..	25	Distinct earthy.	0.106	.014	0.000	0.070	1.2	80.0	13.0	16.3	62.9	600
Winooski River below village.[a]	.....do	30	.....do	.144	.040	.000	.110	1.4	83.0	16.0	19.3	61.4	4,400

[a] *B. coli* present.

The course followed in taking the samples of September 25 is indicated in fig. 7. The center was chosen at the mouth of Winooski River, and from there three lines were extended—one to the northwest toward Colchester Point, another due west, and a third southwest, swinging around Appletree Point to Appletree Shoal, and ending in a broad curve around the southern end of Burlington breakwater at the outfall sewer of the city. The results of analyses taken at the points chosen serve to show the extent of pollution from Winooski River, and the southerly line, designated line A, is designed to give information concerning any continuity in the generally polluted condition which exists between the mouth of Winooski River and the outfall sewer of Burlington. The determinations of value in such a series consist of the number of bacteria per cubic centimeter and the presence of *Bacillus coli communis*. By reason of unfortunate circumstances it was impossible to secure more than the results of the determination of the presence of intestinal bacteria, but the evidence brought out by this determination is so clear and convincing that it is believed that the omission does not weaken in any way the evidence presented. The results of the series of samples taken are shown in

Table XXIII. The samples along the B and C lines were taken at distances of about one-half mile, extending from the center, while along the A line the intervals chosen were considerably shorter—from about one-fourth to one-third mile—located according to observed con-

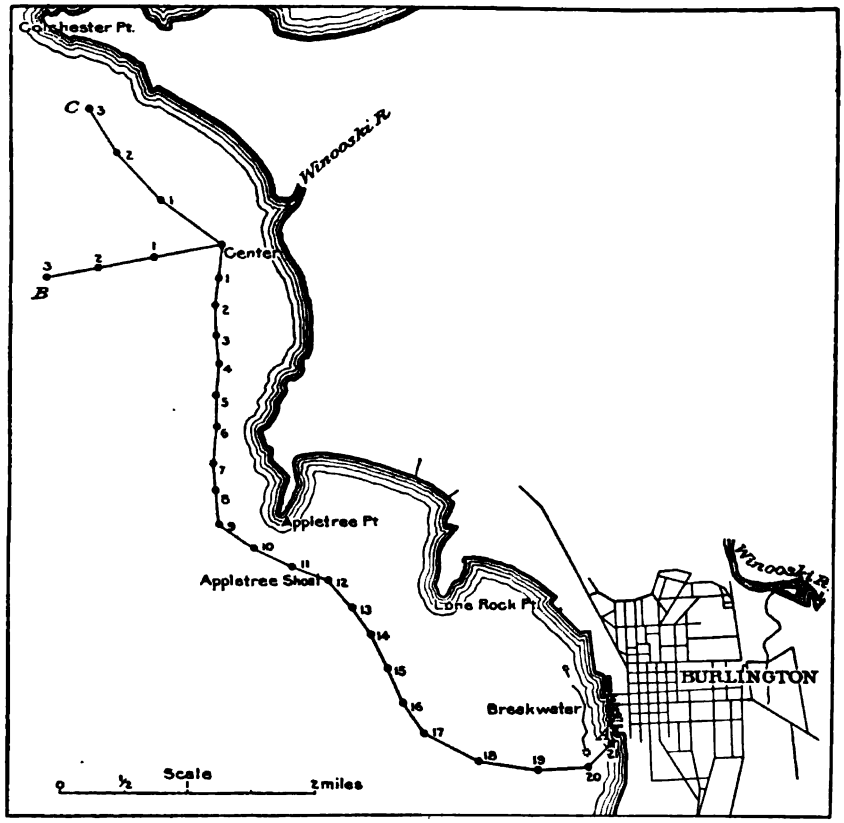


FIG. 7.—Burlington and Winooski sample series of September 25, 1904.

ditions of current and appearance of water, and fixed by intersecting lines running from various stationary points. It will be noted that sample 12 is at Appletree Shoal, directly over the mouth of the intake pipe.

TABLE XXIII.—*Examination for Bacillus coli communis in sample series of September 25.*

C LINE.	
Center	Present.
1	Do.
2	Do.
3	Do.
B LINE.	
Center	Present.
1	Do.
2	Absent.
3	Do.
A LINE.	
Center	Present.
1	Do.
2	Present.
3	Do.
4	Do.
5	Do.
6	Do.
7	Do.
8	Do.
9	Absent.
10	Present.
11	Do.
12	Do.
13	Do.
14	Do.
15	Absent.
16	Do.
17	Do.
18	Present.
19	Absent.
20	Present.
21	Do.

The data in the above table show the presence of intestinal bacteria along the C line—that is, along a line practically parallel with the shore northwestward from the river. Along the B line the bacteria were absent at the two outer sampling points. In other words, the conditions at these two points approach those of the normal broad lake. The A line is the interesting and important one, as it shows a practically continuous record of intestinal pollution from the mouth of the river until point No. 9 is reached, directly west of Appletree Point. This is an exposed position at which the purifying effect of dilution from the broad lake would be most likely to persist. The record further shows that intestinal bacteria were present at all sampling points and down to No. 15, which includes the sample taken at the mouth of the Burlington water-intake pipe. From points Nos. 15 to 17, inclusive, no bacteria were noted, but at points Nos. 18, 20, and 21 they were again isolated. Abundant evidence of the presence of this germ in this region is also shown by the second and third sample series of September 22.

CONCLUSIONS.

The data show clearly that the sewage of Burlington and from Winooski River pollutes practically the entire shore from Colchester Point to Shelburne Bay and includes within the contaminated area the water intake of the Burlington city supply. How much more extensive the effect of pollution from these two points may be, opportunity was not afforded to determine. The area included within the investigation is sufficiently large to indicate the general pollution of the

water in this vicinity. In connection with the report on the early conditions of the Burlington water supply mentioned on pages 68–74, it was shown that evidence concerning the persistence of sewage matter in the lake is particularly elusive and that the best method of identifying the unfavorable effects of Burlington sewage disposal was found to be in the improvement which was shown in the occurrence of intestinal diseases in the city. There has been no general inquiry with reference to the abnormal amount of so-called diarrhea in Burlington since the investigation made by Professor Sedgwick. Nevertheless, the typhoid records in that city are not such as to inspire confidence in the water supply. A report of the local board of health shows the following typhoid records:

Typhoid cases in Burlington, Vt., 1900–1904.

Year.	Cases reported.	Deaths.
1900		7
1901	22	3
1902	19	3
1903	29	2
1904 [a]	31	

[a] To November 25.

The record of deaths from typhoid in the year 1904, up to November 25, was not available, and the report of the number of cases is probably not correct. Local officials state that many of the typhoid cases which have occurred during the year 1904 are not yet reported to the health officer, and that when the final returns are made the number stated above will be increased materially. Compared with the earlier conditions stated in the report of Professor Sedgwick, the present death rate from typhoid appears to be no greater, but, although the earlier morbidity statistics are not available, it is generally admitted by those conversant with the typhoid history of Burlington that the disease is more prevalent than formerly. Dr. B. H. Stone, director of the laboratory of hygiene at Burlington, has reported that 33 per cent of the daily samples of Burlington water taken from the laboratory tap during the month of November showed the presence of *Bacillus coli communis*. For each of these determinations only 1 cubic centimeter of the water was subject to examination.

Considering the results of the sample series stated in previous pages, the degree of prevalence of typhoid fever in Burlington, and the results of examinations made at the State laboratory, it appears to be unquestionable that the sewage of Burlington and Winooski River is highly damaging to the lake in that vicinity. The area in which *Bacillus coli*

communis was identified is much larger than that comprised in any of the other investigations where specific examination was made for evidences of pollution. Burlington is undoubtedly the source of the most serious contamination occurring in the lake.

UPPER END OF LAKE CHAMPLAIN.

SODA-MILL AND SEWAGE POLLUTION.

It has been explained that the investigation of the effect of wastes from the mill of the Ticonderoga Pulp and Paper Company must receive interpretation different from that involved in the three cases treated on previous pages. Wastes from the sulphite-pulp mill at Ausable Forks, from the soda-pulp mill at Willsboro, and from the city of Burlington and Winooski River discharge into the broad lake where the water is normally clear and of excellent physical appearance and where the volume of lake water affords excellent facilities for dilution and sedimentation.

That part of the lake into which the Ticonderoga pulp-mill pollution flows is narrow and shallow, affording far less opportunity for dilution and sedimentation than the broad lake. This condition would serve to make the identification of wastes less difficult than in the case of the first three investigations. On the other hand, such identification is rendered more difficult by reason of the fact that this part of the lake contains water far inferior to that of the broad lake. Bordered and underlain by clay, the water contains a greater amount of suspended material. The amount of this material, too, varies enormously. The water is profoundly stirred by high winds from certain directions, and large quantities of mud from the bottom and the banks are brought up and become suspended material. Thus the condition of the water is largely a reflection of the direction and violence of the wind. A second feature affecting the condition of the water is the amount of precipitation in the immediate drainage area surrounding it; after heavy rains large amounts of foreign matter in suspension are washed into the lake. These facts render the detection of pollution from the mill into the lake more complicated than it would be if the water were like that of the broad lake, and more than compensates for the advantages arising from the comparatively small volume of water into which the wastes are turned.

The soda process is used at the Ticonderoga mill, and therefore the special features of the investigation are similar to those reviewed in the case of the Willsboro mill. In the interpretation of results there are, however, modifying features other than those above mentioned as due to the peculiar characteristics of lake water. In the case of the Willsboro pollution it was demonstrated that only the wastes from the mill were to be considered, no sewage in perceptible amount

A. WATER POWER OF TICONDEROGA PULP AND PAPER COMPANY, TICONDEROGA, N. Y.

B. VIEW AT TICONDEROGA, N. Y.

being demonstrated. In the present case, however, there is a complication which arises from the discharge of sewage from Ticonderoga village, which contains 1,911 inhabitants (Pl. XI, *B*). There is also a considerable amount of ground wood which is wasted from the mechanical pulp mills situated on Ticonderoga Creek above the village (Pl. XI, *A*). These wastes undoubtedly modify the effect of the mill waste and must be taken into consideration in interpreting the results of the analyses.

CHARACTER OF UPPER-LAKE WATER.

Before taking up the study of the character and effect of the polluting matter, it will be necessary to determine, as clearly as possible under the existing conditions, just what is the normal character of the water in this portion of the lake, so that some standard may be adopted with which the specific determinations made for the purpose of tracing the polluting matter may be compared. It will be seen, on examination of the conditions in this part of the lake, that the selection of a point at which a normal sample can be taken is rather difficult. At the head of the lake is the village of Whitehall, containing 4,377 inhabitants. The sewage from this place is discharged into the lake; therefore, at its very head the lake is polluted, and as the current flows northward there must be some effect upon that part of the lake in the region of Ticonderoga.

But the distance from Whitehall to Ticonderoga by lake is 22½ miles, and, as the rate of lake flow is slow, it is practically certain that the effects of sewage matter are largely if not entirely overcome in that distance. In fact, it may be stated with confidence that the only possible chemical evidence of Whitehall sewage in the lake above Ticonderoga Creek will be the slightly higher proportion of chlorine. Therefore a sample taken from such a point will represent practically the normal water of the lake, if the possibility of back flow from Ticonderoga Creek up the lake be eliminated. Bearing this in mind, a sample was taken one-half mile south of Chipmans Point (fig. 8, p. 101). The distance from Whitehall to this sampling point is 19 miles, and from the mouth of Ticonderoga Creek 3½ miles. The sample was taken on August 27, 1904. For several days prevailing winds had blown from the south, and at the time of sampling and for eighteen hours previous the wind from this direction had been uncommonly strong. This fact, together with the distance uplake from the mouth of the creek, makes it fairly certain that no Ticonderoga pollution was encountered.

The results of analyses of this water are as follows:

TABLE XXIV.—*Analysis of water from Lake Champlain one-half mile south of Chipmans Point.*

[Parts per million.]

Mineral.		Sanitary.	
SiO_2	11.2	Color	1.5
$Fe_2O_3 + Al_2O_3$	4.2	Odor	2 E.
CaO	28.07	Albuminoid ammonia	0.116
MgO	9.79	Free ammonia	0.02 +
Na_2O	4.66	Nitrites	0.000
Cl	1.2	Nitrates	0.030
SO_3	24.4	Chlorine	1.200
CO_2	21.93	Total solids [a]	109.000
	105.45	Volatile solids	25.0
O replaced by Cl	.54	Per cent volatile	22.9
Total solids [a]	104.91	Alkalinity	65.0
		Hardness	80.0
		Bacteria per cubic centimeter	1,200
		B. coli communis	Absent.

[a] The difference in the amount of residue in the analyses is explained by the fact that samples for the mineral and the sanitary analysis were not taken at the same hour nor in exactly the same place.

The data set forth in the mineral analysis above show that the amounts of lime, magnesia, and silica are considerably larger than those determined in the water taken from the broad lake, while the sulphates exceed those previously determined by a still greater proportion. It is important to note that the amount of soda in this part of the lake is lower than that shown in Table III. As soda is one of the principal constituents of the waste from the Ticonderoga mill, an increase in the amount of this substance in the lake in the region about the mouth of Ticonderoga Creek will be one of the most concise demonstrations possible concerning the effect of the waste. It should be borne in mind, however, that inasmuch as the calcium, largely in the form of calcium carbonate, is in high proportion in the water from this end of the lake, the alkalinity must be higher than that in the broad-lake water.

Considering the sanitary analysis above set forth, it will be seen that the amount of dissolved residue is considerably greater than that determined for the broad lake, while the proportion of volatile solids is smaller. This indicates that by far the greater proportion of the dissolved matter is inorganic. The degree of hardness which corresponds to the excess of calcium and magnesium noted in the mineral analyses is considerably higher than that noted in the broad-lake

A

B

WATER POWER OF INTERNATIONAL PULP COMPANY, TICONDEROGA CREEK.

A, "A" mill; *B*, "B" mill.

samples. It will be noted further that the number of bacteria per cubic centimeter in this part of the lake is high, while *Bacillus coli communis* is absent. The bacteria found in the sample are presumably not of sewage origin, but accompany the suspended matter in the water and have their origin in purely local and natural features.

CHARACTER OF TICONDEROGA CREEK WATER ABOVE PULP MILL.

The water in Ticonderoga Creek, as it emerges from Lake George, is clear and of excellent quality. It contains 10.63 parts per million of lime, 5.31 parts of magnesia, 5 parts of silica, and small proportions of iron, alumina, and soda. The sanitary analysis reveals no odor, a slight color, practically no turbidity, 37 parts per million of residue, 40 per cent of which is volatile, 0.09 parts of albuminoid ammonia, 0.008 parts of free ammonia, no nitrites, 0.04 parts of nitrates, and 0.05 parts of chlorine. The hardness is 26 parts per million, stated in terms of calcium carbonate.

A short distance below Lake George the creek passes two groundwood pulp mills (Pl. XII, *A* and *B*), which formerly discharged considerable quantities of waste pulp into the water; improvements have been made recently. Upon reaching the upper limit of the village of Ticonderoga the creek passes over clay beds and immediately becomes turbid. This condition becomes more pronounced as the stream passes through the village to the headgates of the water power which operates the Ticonderoga pulp mill (Pl. XI, *A*). Here the water has an offensive appearance and odor, due to the refuse turned into the creek from the village (Pl. XI, *B*). This was found to be a convenient sampling point to determine the effects of sewage on the stream without the complications arising from the Ticonderoga mill waste, as all waste from this mill is turned into the stream some distance below.

The following table contains the results of an analysis of the water at this point:

TABLE XXV.—*Analysis of water from Ticonderoga Creek below Ticonderoga mill and above chemical pulp mill.*

[Parts per million.]

Mineral.		Sanitary.	
SiO_2	6.0	Total solids	56.0
$Fe_2O_3+Al_2O_3$	4.6	Albuminoid ammonia	.086
CaO	13.20	Free ammonia	.000
MgO	4.15	Nitrites	.000
Na_2O	3.231	Nitrates	.050
Cl	1.5	Chlorine	1.5
SO_3	4.4	Hardness	33.8
CO_2	13.83	Alkalinity	30.0
	50.91	Bacteria per cubic centimeter	72,000
O replaced by Cl	.69	*B. coli communis*	Present.
		Turbidity	(a)
Total	50.22		
Total solids, including organic matter	55.8		

a Considerable.

The points to be noted in the above analysis are:

(1) The increase in the amount of lime over that shown in the water at the head of the creek, 1½ miles away. This is due largely to the wastes from the paper mill of the Ticonderoga Pulp and Paper Company just above. These wastes consist largely of water which is used in the beaters to wash and separate the pulp fibers, with a small amount of chalk.

(2) The considerable increase in chlorine over that at the head of the creek, undoubtedly due to Ticonderoga sewage.

(3) The increase in hardness corresponding in a measure to the increase in lime.

(4) The enormous number of bacteria and the presence of *Bacillus coli communis*, due to sewage.

(5) The high turbidity which results in part from the paper-mill waste above mentioned, but principally from the clay beds over which the creek runs as it enters the village of Ticonderoga.

TICONDEROGA PULP AND PAPER COMPANY.

The plant of this company is located upon the right bank of Lake George outlet near the eastern border of the village of Ticonderoga. It is composed of two parts, one of which is largely devoted to the

manufacture of wood pulp from poplar wood by the soda process, while in the other paper manufacturing is exclusively carried on. From the former plant there are discharged the trade wastes usually occurring in this process, while from the latter plant the only waste consists of large volumes of wash water contaminated to a very slight degree by chalk and the negligible amount of chemicals which seem inevitable in pulp after it has been submitted to the usual washing processes in the pulp mills. A large part of the water, however, which is discharged from this paper mill is practically pure, it being used merely to bring the pulp to such a fluid state that it can readily be handled in pipes and wet machines by pumps or gravity. So far as the question of water pollution is concerned, the main interest in the plant belonging to the Ticonderoga Pulp and Paper Company is centered in the pulp mill (Pl. XIII, *B*).

MANUFACTURE OF THE PULP.

The method of manufacturing pulp by the soda process has already been described (see pp. 24–33) in connection with the discussion of the effect of the mills of the New York and Pennsylvania Company at Willsboro upon Bouquet River and Lake Champlain. Save for a few minor details in the process of treating the digested pulp, the description there given is sufficient for present purposes. The variations in the process of washing the crude pulp are, however, sufficiently broad to make it advisable to consider them briefly, in order that any differences which may appear in the effluents of the two mills may be explained.

The process of washing the crude pulp at Ticonderoga differs from that at Willsboro in that there is no use of waters containing weak solutions from previous washings. As soon as the wash pan is filled from the blowpit, the valve at the bottom of the pan is opened and the liquid contents are pumped directly to the soda-recovery plant. Simultaneously a stream of fresh, clear water is turned into the top of the pan. Thus as fast as the contents are drawn off at the bottom uncontaminated water takes their place at the top, and as the strong soda liquor is drawn lower and lower the fresh water progresses farther into the depths of the tank, there being a fairly strong demarcation between the original strong liquor and the wash water. The end of the washing is noted when the original soda liquor is entirely withdrawn from the pan and the wash water appears at the lower valve. Theoretically the contents of the pan are then pumped in the usual way to go through the more advanced stages of the process; practically this is not accomplished. Large quantities of wash water containing soda are diverted from the pipe leading to the soda-recovery plant and discharged into the tailrace of the mill, and thence find their way into the creek. The concentration of this solution is not high, and varies from time to time. Nevertheless, the total amount

lost in the course of a year must be considerable, and, in addition, it adds to the burden of the stream. In order to secure some idea of the amount of soda lost in this way, four samples of this liquor were collected from one of the vats during the period of the washing. The first was taken at the time the wash water was first turned into the mill race, and the second, third, and fourth were collected thirty minutes, one hour, and one and one-half hours later, respectively. The amounts of soda in these samples were then determined and found to be as follows: No. 1, 960 parts per million; No. 2, 720 parts; No. 3, 528 parts; and No. 4, 424 parts. The flow of this liquor into the creek continued for a considerable time after taking the last sample, or probably a total period from start to finish of two hours. No records of the amount of liquor so discharged were obtainable, but it will readily be understood that, although the individual samples do not reveal any commercially great amount of soda, the constant flow from at least one of the 8 wash pans installed in this plant, each provided with 2-inch outlet pipes, must finally result in a large loss of soda and a corresponding increase in stream pollution. Whether this increase has any practical deleterious effect remains to be seen, but the facts must be noted in connection with the investigation. A part of this liquid waste which is conducted into the tailrace of the mill consists of organic extractives of the wood. In the case of the Willsboro mill it was noted that no organic matter entered into the pollution question. This can not be said with reference to the waste from the Ticonderoga mill. At the beginning of the diversion of this liquor into the tailrace the color is high, indicating a considerable amount of organic matter, which upon examination was found to be present. In comparison with the sewage which is turned into the stream from the village of Ticonderoga the total amount of the organic matter thus emptied into the tailrace is probably very small. Nevertheless, its presence must be recognized in determining whatever effect there may be upon the lake by reason of the operation of this mill.

SEDIMENTATION BED.

Across the river from the mill is a sedimentation bed covering about 15 acres (Pl. XIII, *A*), into which the lime sludges from the causticizing and bleach-liquor plants and the black-ash sludge from the recovery plants are turned. This sedimentation bed does not differ materially from that at Willsboro. Its function is merely to separate the solid from the liquid effluent and allow the latter to pass into the river unchanged except by those variable, natural, and indefinite processes which are commonly recognized in such cases.

This sedimentation bed is situated on the site of what was formerly a low, swampy piece of ground, and at the present time the level has been raised to a height of about 12 feet. From the standpoint of

A. SEDIMENTATION BED OF TICONDEROGA PULP AND PAPER COMPANY.

B. MILLS OF TICONDEROGA PULP AND PAPER COMPANY.

effectiveness it probably performs the work expected of it, and there has never been any suggestion that during freshets in the spring the contents were washed into the lake. From the standpoint of an efficient sedimentation bed, planned and operated according to scientific principles, it does not in anywise fulfill the requirements. These objections are not of public concern. The disadvantages arising from them are solely those of lack of economy on the part of the company operating the mill. Tests of the effluent liquor show that it contains 92.7 parts per million of chlorine and 338 parts per million of alkalinity, stated in terms of calcium carbonate.

An interesting feature in connection with the establishment of the Ticonderoga sedimentation bed upon the low ground east of the village has been noted in connection with the occurrence of malarial diseases in the vicinity. Previous to the installation of the works such diseases were extremely common and caused no little amount of inconvenience, suffering, and expense. Since its installation, according to the testimony of physicians practicing in Ticonderoga, there have been practically no malarial cases demanding attention. This effect is probably due to the covering up of the stagnant ponds in this locality, thereby destroying the breeding places of the particular genus of mosquito which transmits the organism causing this disease. While there has been no little stagnant water collected about the bed, the presence of large amounts of lime has been effectual in either destroying the mosquito larvæ or preventing the hatching of the eggs.

EFFECT OF MILL WASTES.

EFFECT ON TICONDEROGA CREEK.

The Ticonderoga pulp mill is situated at the foot of the lowest fall on Ticonderoga Creek, below which the stream is quite flat. At low-water periods there is practically no current. Sewage matter, sawdust, and fine pulp have been deposited upon the bed of the stream in such quantities that, with the exception of a few inches just below the surface, the channel contains a thick, heavy mass of suspended matter extending for a considerable distance downstream toward the lake. Lower down the water continues shallow and the bottom is covered to a depth of at least 1 foot with a fine, highly organic silt. A small steam tug which draws freight boats up and down the stream forces its way through this mud, the propeller throwing up the material and revealing in no uncertain manner its unspeakable condition. Bacteriologists would expect to find there an advanced state of putrefaction, extremely foul odors, and millions of bacteria per cubic centimeter. In point of fact there appears to be little putrefaction, and no odor except that characteristic of the inorganic waste from the pulp mill. The number of bacteria is 102,000 per cubic centimeter, far less than

might be expected under such conditions, while *Bacillus coli communis*, so abundant in the river above the mill, is absent below.

This can be the result of nothing else than the disinfecting properties of the pulp-mill waste. The report of E. B. Phelps, set forth in subsequent pages, shows unmistakably that such waste is an excellent germicide. Therefore, while it may be detrimental to a stream not otherwise polluted, like Bouquet River, the waste certainly has beneficial effects upon a stream highly polluted with organic wastes, like Ticonderoga Creek.

The analysis of water from Ticonderoga Creek below the outlet of the sedimentation bed adjoining the pulp mill gives the following results:

TABLE XXVI.—*Analysis of water from Ticonderoga Creek below sedimentation bed of Ticonderoga Pulp and Paper Company.*

[Parts per million.]

Mineral.		Sanitary.	
SiO_2	8.80	Total solids	67.000
$Fe_2O_3 + Al_2O_3$	4.80	Albuminoid ammonia	.090
CaO	15.53	Free ammonia	.020
MgO	6.64	Nitrites	.000
Na_2O	4.72	Nitrates	.040
Cl	2.90	Chlorine	2.800
SO_3	6.90	Hardness	42.900
CO_2	17.19	Alkalinity	32.000
	67.46	Bacteria per cubic centimeter	102,000
O replaced by Cl	1.31	*B. coli communis*	Absent.
Total solids	66.15		

Comparison of creek waters above and below mill.—The important points of information afforded by Tables XXV and XXVI are:

(1) The amounts of lime and soda. It will be noted that the proportion of these constituents in the water taken from the stream below the sedimentation bed is but slightly greater than that above the mill. It might be expected that, inasmuch as there is a considerable amount of soda turned into the stream at the tailrace, as described on page 96, and large quantities of lime are deposited upon this sedimentation bed, which drains directly into the stream just above this sampling point, there would be a corresponding increase in these compounds in the water. The absence of such increase is very remarkable and seems to throw doubt upon the data submitted in Table XXVI. These

results are, however, confirmed by the hardness and alkalinity determinations in the sanitary analysis. The former is only 9.1 parts per million greater below the mill than above it, and it will be noted that a large part of this excess may be accounted for by the increase shown in the amounts of magnesia and sulphates. The alkalinity, on the other hand, is greater by only 2 parts per million below the mill than above. This supports the lime and soda determinations and strengthens the supposition concerning the cause of the disproportionate increase in hardness, for, as is well known, the sulphates of the alkaline earths are included in the hardness determination, but not in that of alkalinity. That the increase in the amount of soda is so slight is due to a variety of causes, the most important of which is dilution by Lake George water.

(2) The proportionately large increase in the amount of chlorine, which is plainly not due to additional sewage contamination, but to the spent bleach turned into the sedimentation bed. This bleach, as shown in the discussion of the Willsboro mill, still contains considerable amounts of chlorine.

(3) The high free ammonia, with no nitrites and low nitrates, pointing in a general way to arrested oxidization of organic matter.

(4) The number of bacteria per cubic centimeter, already referred to on pages 97–98, and the absence of *B. coli communis*.

Comparison of creek and lake waters.—It will be of advantage now to compare the mineral analyses of the water taken from Ticonderoga Creek below the sedimentation bed with that of the lake above the influence of Ticonderoga Creek pollution. It is plain that the results of Ticonderoga Creek pulp-mill pollution will be most prominent and their effects most acute in the stream just below the point at which they are discharged from the mill. The difference between the water at this point and that of the normal lake represents the greatest measure of influence which such waste could possibly have upon the lake. It has already been demonstrated that the mill waste consists almost entirely of lime, soda, and chlorine. Therefore the excess in the amount of these ingredients in the water of the stream over the amount of the same in the lake may be accepted as an indication of the possibility of identifying the waste after it has mingled with the latter.

The analyses are set forth in a form convenient for comparison below:

TABLE XXVII.—*Comparative analyses of water from Ticonderoga Creek below sedimentation bed and from Lake Champlain above influence of creek water.*

	Creek.	Lake.		Creek.	Lake.
SiO_2	8.80	11.20	Cl	2.90	1.70
$Fe_2O_3+Al_2O_3$	4.80	4.20	SO_3	6.90	24.40
CaO	15.53	28.83	CO_2	17.19	22.08
MgO	6.64	9.78	Alkalinity	32.00	65.00
Na_2O_3	4.72	4.58			

The amount of lime in the normal water of the lake is shown to be nearly twice as high as that in the most polluted portion of the creek. Therefore this ingredient must be left out of consideration. It may be safely stated that, whatever effect the Ticonderoga pulp-mill waste may have upon Lake Champlain, it does not contribute as much lime as the lake already contains.

Although the amount of sodium in the creek water is slightly greater than that in the lake, the difference is so small that, with the small volume of creek water merged with the large volume of the lake, the identity of the former, so far as the amount of sodium is concerned, would be completely lost. Indeed, it is known that the alkalinity of the water at the northern end of the lake varies by an amount greater than would be produced by the above difference in sodium, even if such were added to or taken directly from the lake water. There are, it is true, similar variations in the quantity of sodium found in the creek water, but the change would hardly go in the direction of higher concentration. The creek, at the time of sampling, was exceptionally low and the concentration of soda about as heavy as it is ever likely to become. Therefore the comparison above made is an extreme one. Under ordinary conditions the soda in the creek will be even less than appears in the above analysis. All things considered, there is absolutely no promise in the determination of lime, soda, or alkalinity, so far as it relates to the tracing of pulp-mill waste.

The amount of chlorine in the creek appears much greater than that in the lake. This, then, may serve as a specific test by which the waste may be traced. The amount of chlorine in the creek above the Ticonderoga pulp mill and just below the village was, according to the table, 1.5 parts per million; therefore all the chlorine contributed by the creek to the lake does not originate in the mill waste. The proportionate amount from the mill may be roughly considered to be the

difference between 2.9 parts and 1.5 parts, or 1.4 parts per million, a smaller amount than was found in the normal lake. Thus it is shown

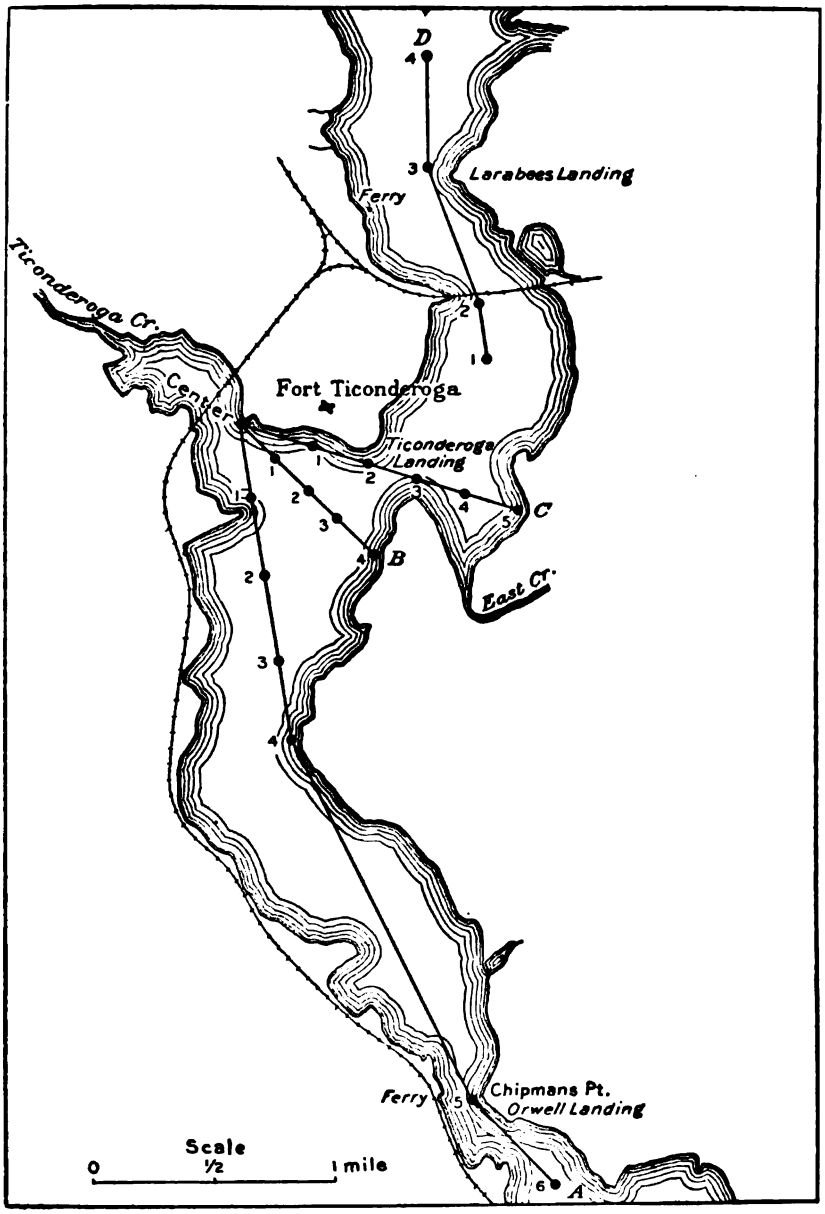


FIG. 8.—Ticonderoga sample series of August 27, 1904.

that the entire amount of chlorine turned into the lake does not originate in the mill. On the other hand, the amount of chlorine in the

water just above the mill is practically the same as that in the lake, and it follows that if the waste were eliminated from the creek the creek water as it merges into the lake could not be distinguished from the lake water by the chloride test. The difference between the chlorine content of the two waters is therefore due entirely to pulp-mill waste, and any identification of creek water which may arise from this test may be charged unmistakably to the pulp mill. It is highly important to note these facts, in order that no doubt or misconception may arise as to the effect of Ticonderoga sewage and its relation to the chlorine in the water of the lake.

EFFECT OF WASTES ON LAKE CHAMPLAIN.

Sample series of August 27.—Arrangements were made to collect a series of samples radiating from a center at the mouth of the creek, along three lines, A, B, and C, and along a fourth line running from a point one-fourth mile south of the Rutland Railway bridge to a point about one-half mile north of Larrabee Landing, along the mid-channel of the lake (fig. 8). These samples, as explained in previous investigations, will serve to show the persistence of mill waste in the lake. Line A extends from the mouth of the river in a general southeasterly direction to a point one-half mile beyond Chipmans Point; line B extends from the same center directly across the lake to the opposite shore, while line C, starting at the same point, runs close to the point upon which old Fort Ticonderoga stands, and thence directly across to the opposite shore. The fourth line, which is designated "D," runs as above described.

The wind on the day of sampling, and for some days previous, had been from the south, and at the time of sampling was blowing strong. This would lead to the expectation that the greater amount of evidence concerning the persistence of the mill waste would appear in the lake to the north of the creek. The results are shown in Table XXVIII.

TABLE XXVIII.—*Ticonderoga sample series of August 27, 1904.*

[Parts per million.]

A LINE.		C LINE.	
Sampling point.	Chlorine.	Sampling point.	Chlorine.
Center	2.8	Center	2.8
A–1	1.5	C–1	3.0
A–2	1.8	C–2	2.4
A–3	1.9	C–3	2.4
A–4	1.7	C–4	2.1
A–5	1.1	C–5	2.2
A–6	1.2		
B LINE.		**D LINE.**	
Sampling point.	Chlorine.	Sampling point.	Chlorine.
Center	2.8	D–1	2.2
B–1	1.8	D–2	2.2
B–2	1.9	D–3	2.2
B–3	1.9	D–4	1.7
B–4	1.9		

The samples taken along line A show the persistence of the waste in that portion of the lake south of the creek. In view of the fact that the lake flows north, and that the wind, previous to sampling, was from the south, the appearance of abnormal chlorine in the direction opposite to that of the wind and the natural flow gives exceptionally strong evidence concerning the effect of the mill waste upon the lake. That this abnormal chlorine has no other origin is shown by the fact that the samples taken at points 5 and 6 (fig. 8), 3½ miles to the south of the creek, contained the normal amount. No sources of pollution appear between points 4 and 5 to account for the increase. Line B gives evidence similar to line A, while along line C the effects of the wind in blowing the waste northward from the mouth of the creek are clearly shown. The evidence given by the determinations along line D is corroborative.

The wastes from the mill of the Ticonderoga Pulp and Paper Company, situated on Ticonderoga Creek, persisted in Lake Champlain on August 27, 1904, a distance of at least 1¼ miles south of Ticonderoga Creek against wind and current, and were plainly apparent nearly 3 miles down the lake. How much farther in the latter direction the evidence might have been procured is not known. The distance traversed is sufficient for all purposes.

Sample series of September 9.—Another series of samples was taken on September 9, 1904, in order to verify or disprove the existence of the general conditions shown in the series of August 27. The conditions under which the later work was done were similar in all essential respects to those of the earlier work, except that the wind was blowing a gale from the north. The surface current was then opposed to that known to exist at depths below the influence of the wind. An opportunity was thereby afforded to contrast the course taken by the mill waste under conditions extremely different from those in the first series.

Before considering the series of samples, it will be advisable to contrast the characteristics of the water in the creek and in the lake above the influence of creek pollution. The alkalinity and chlorine contents in the water of the creek above and below the pulp mill and in the lake at point 9, line A (fig. 9), are shown in the following table:

Alkalinity and chlorine in Ticonderoga Creek and Lake Champlain.

[Parts per million.]

	Chlorine.	Alkalinity.
Ticonderoga Creek above pulp mill	1.2	27
Ticonderoga Creek below sedimentation bed	6.0	31.5
Lake at point 9, line A	.9	77

It will be noted, by comparing the above results with those obtained at similar points in the series of August 27, that the water from the creek above the pulp mill and that in the normal lake do not differ essentially in respect to chlorine and alkalinity, but the amount of chlorine is considerably larger in samples taken below the sedimentation bed on September 9 than on August 27. This may be explained entirely by the varing conditions in the mill and in the sedimentation bed. In the treatment of bleaching powders in the mill it is the intention, as explained on previous pages, to remove from that powder all the available chlorine. In practice, however, this is not done, and there always remains a small amount of chlorine in the lime sludge which is turned into the sedimentation bed. This amount varies within limits greater than those indicated by the determination of chlorine in the water taken from the creek below the sedimentation bed in the two series. The condition of the sedimentation bed, too, might suffice to explain this difference. It is impossible, in the intelligent management of a sedimentation bed of the character of that installed at Ticonderoga, to turn the waste always in the same direction upon the bed. On one day the liquid waste may, by reason of inequalities in the surface of the bed,

take a long detour around the bed or be largely held back by deposits of sludge; on another day the course of the waste from the head of the sedimentation bed to the outlet at the foot may be more direct, and

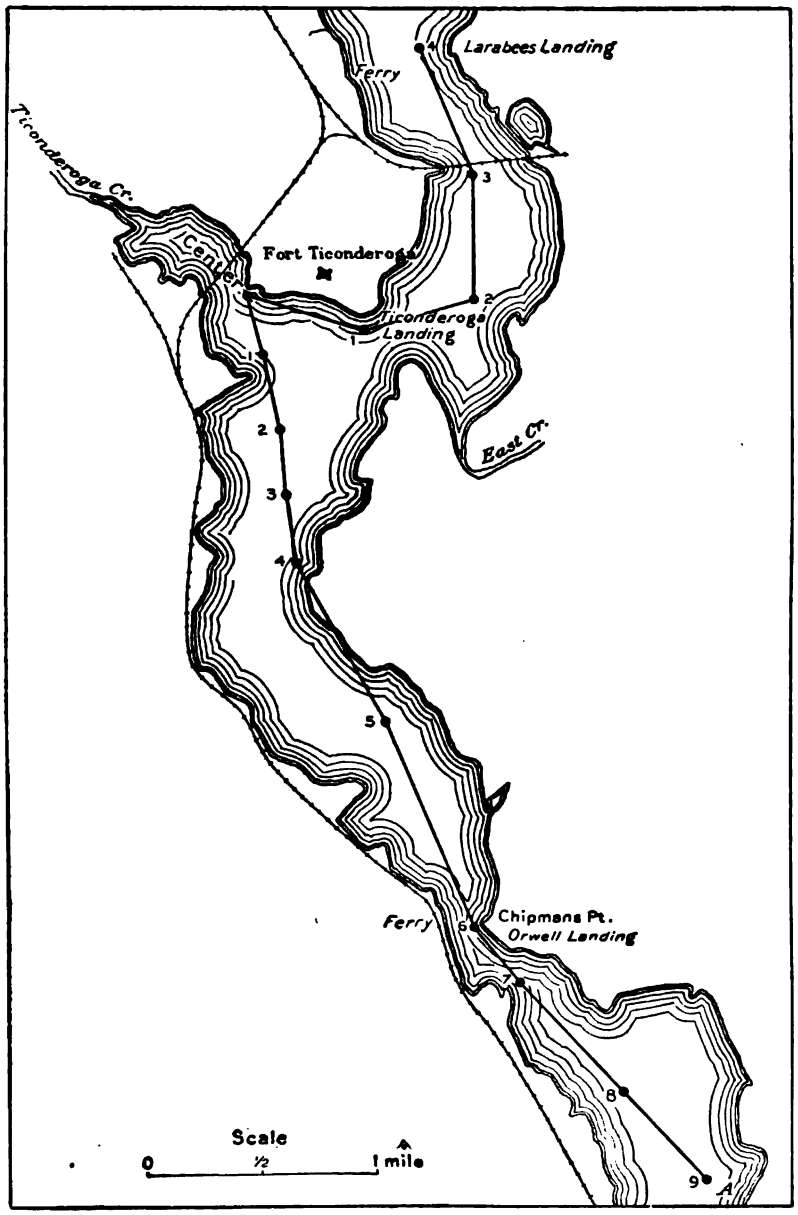


FIG. 9.—Ticonderoga sample series of September 9, 1904.

large amounts of liquor may be emptied into the stream within a short period. These facts are easily demonstrated by observing the surface of the bed and the direction of the currents over it.

This great excess in the amount of chlorine in the water of Ticonderoga Creek below the sedimentation bed, over that observed in the previous series, does not vitiate any of the conclusions drawn from the results of the determinations in that series. As long as the comparative values in each series are kept in mind and allowed for, the variation in either of the constituents from series to series does not affect the interpretations. The problem in hand is one of comparative values rather than absolute ones, and such comparisons can be made equally as well under diverse conditions, so long as these conditions are determined.

It will be seen in this series that the difference between the amount of chlorine in creek water above the pulp mill and that in the lake at point 9, line A, is only a small amount, and if the waste were excluded from the creek the water of the creek, when merged into that of the lake, could not be identified by the chlorine determination. This assumption is identical with that stated in the first series. The fact that a large amount of chlorine was found in the creek water below the sedimentation bed renders the problem of identification in the lake simpler than in the first series. It is apparent that almost all the excess of chlorine in the creek water as it discharges into the lake is due to the pulp mill, and the determination of this chlorine at the various points along the sample lines is specific. In considering the sample series of September 9, it should be borne in mind that, as the wind was blowing from the north, the effects of the waste to the south of the creek should be more apparent than in the series of August 27. The following table gives the results of the chlorine determinations along lines A and B, shown in fig. 9.

TABLE XXIX.—*Ticonderoga sample series of September 9, 1904.*

A LINE.

Sampling point.	Chlorine.	Sampling point.	Chlorine.
Center	8.8	A–5	1.8
A–1	3.1	A–6	1.4
A–2	2.9	A–7	1.0
A–3	2.9	A–8	1.1
A–4	7.6	A–9	.9

B LINE.

Center	8.8	B–3	2.5
B–1	2.9	B–4	2.9
B–2	2.6		

It will be noted, on examination of the data given, that the evidences of Ticonderoga Creek pollution are apparent as far south as sampling point 6, opposite Chipmans Point. The distance from the creek mouth to Chipmans Point is about 3 miles. This is probably as far as the evidence of pulp-mill pollution existed on the day of sampling, for at point 7, about one-fourth mile south of Chipmans Point, the amount of chlorine is normal. Considering line B, it will be noted that marked evidences of pollution extend as far as the samples were collected. This in spite of the fact that for a considerable period a heavy wind from the north had been blowing so strongly that it made a farther extension of the line of samples hazardous to the collectors. The persistence of this chlorine down the lake does not necessarily show that the water of the creek had proceeded against the wind up to point 4, but that the lake in that region and for a considerable distance to the north contains a high amount of chlorine due to the constant pouring out of waste from Ticonderoga Creek, and that the condition along the entire lake to the north has become general.

The sample series of September 9 corroborates that of August 27, and gives assurance that the waste from the Ticonderoga pulp and paper mill exerts a considerable influence up and down the lake from the mouth of Ticonderoga Creek. That this should be the case is not surprising. As has already been stated, the lake in this region is narrow and shallow, and its power to conceal foreign matter is far less than that of the broad lake opposite the mouth of Bouquet River. It may be safely stated, then, that the effect upon the lake of Ticonderoga Creek, with its burden of pollution, is unmistakable.

CONCLUSIONS.

The determination of whether the waste from the Ticonderoga pulp mill may be identified in the lake is but a part of the problem concerning which the investigation was made. Having shown that the wastes do persist in the lake, it becomes necessary to consider whether or not such wastes have a deleterious effect. It has been maintained on previous pages that the waste from a soda-pulp mill is entirely inorganic, and the experiments which were made in connection with waste from the Willsboro mill fully substantiate this claim. It has also been shown that the waste from the Ticonderoga mill is practically the same as that from the Willsboro mill. Therefore the decision concerning the possible deleterious effect of this waste on the lake must be based upon the influence which lime, soda, and chlorine would have on the water.

The analytical statements on previous pages have demonstrated that the amount of lime and soda in the creek at the point at which it is most concentrated is less than that which normally occurs in the lake.

This was clearly shown by the actual determinations of lime and soda and by repeated determinations of alkalinity. Therefore it is a safe assumption that the amount of these substances discharged from the sedimentation bed and from the mill does not in any way affect the lake water. Hence the only possible deleterious effect which the mill wastes could have upon the lake results from the increased amount of chlorine which has been shown to be imparted to the water.

Chlorine occurs in water usually in the form of common salt. This is almost invariably true in the waters of the northeastern part of the country, and there is no doubt that the chlorine derived from the Ticonderoga pulp mill is instantly converted into sodium chloride as soon as it mingles with the water. Now, what deleterious effect can be produced by this amount of sodium chloride? In the most concentrated condition in which it has been discovered the amount may still be called extremely low. The majority of healthful water supplies in the United States contain far greater proportions of salt. It is true that the amount of salt in a water above the normal for the region is usually considered by sanitarians as an indication of sewage pollution, but in the present case it has been shown that the amount of salt derived from sewage pollution in Ticonderoga Creek is not greater than that which occurs in the lake. In other words, it is certain that the source of the excess chlorine is the pulp mill. As such it can in no wise be harmful. The increase in chlorine indicated is by no means sufficient to make its presence known to the taste, nor can it in any way affect deleteriously any substance already within the water. Sodium chloride is a most stable salt, and years of research have shown that, except under peculiar circumstances which never take place in this part of the country, it remains in its original condition though almost every other ingredient of the water be changed. The inevitable conclusion must therefore be that the waste from the Ticonderoga pulp mill is in no wise detrimental to Lake Champlain.

GENERAL CONDITIONS IN LAKE CHAMPLAIN.

ALGÆ.

The statement has repeatedly been made that, as a result of the discharge of foreign material into Lake Champlain, there is a superabundance of algæ of the offensive species. In fact, this has been considered one of the main points of evidence in support of the charge that the lake is being damaged by municipal and industrial wastes. Therefore it was believed necessary to give as much attention as possible to this phase of the question. It was impossible to undertake the refined series of experiments necessary for a final opinion on this point, but sufficient observations were made to permit certain generalizations.

GENERAL CONDITIONS OF EXISTENCE.

Nearly all quiescent surface waters contain microscopic organisms in large numbers. The occurrence of these organisms in such waters is as natural as the occurrence of fish. They take their place in the flora and fauna of water life as inevitably as do the water lily, the tadpole, the eel, or the brook trout. The mere presence of algæ in a water is certainly not evidence of any unnatural feature. On the contrary, their absence would be unique. Therefore the supposition that because of a superabundant growth of algæ along the shores of a lake there must be polluting material turned into the water is unfounded.

There are many varieties of algæ. A sample of water from almost any lake will reveal numerous kinds. Nevertheless, they have a seasonal distribution. For example, a certain species may be found in abundance in spring and in only small numbers in summer or autumn; likewise, a different species may be scarce or absent in spring but especially numerous in summer or fall. Similarly, a certain kind of alga may be abundant during one year, but scarce during the next year or a cycle of years thereafter. These variations may be due to causes quite as natural as those which bring about similar fluctuations in the potato, corn, wheat, or cotton crops. The fact that a certain troublesome alga appears along the shores of a lake during several seasons in greater abundance than in former years can by no means be attributed offhand to any change artificially made in the character of the water.

Some organisms thrive under certain conditions of water; therefore the presence of such organisms in exceptional numbers may be taken as an indication of those conditions. On the other hand, the absence of these forms may in many cases be interpreted as an evidence of the nonexistence of those conditions.

Algæ die out unless food material is present, and increase in number as the food is increased. Organic matter, by its oxidization, supplies carbon dioxide and nitrates, which are favorite food for algæ. Therefore, other things being equal, anything which would increase or decrease these products would have a consequential effect upon the number of algæ.

Algæ impart certain appearances, odors, and tastes to the water. Some of these features are the result of life processes of the organisms, while others are due to the products of their death and decay. These odors and tastes have no relation to any polluting material that might be placed in the water, but occur everywhere that the organisms flourish, whether it be in the high mountain lake with no suspicion of artificial contamination, or in a stagnant pond which receives city sewage.

ALGÆ IN LAKE CHAMPLAIN.

The condition of Lake Champlain during the summer of 1904 was not such as to lead the observer to believe that it was abnormally infested with water organisms. It is true that they were abundant, especially during the latter part of August, but no more than the natural conditions would warrant. To the rocks along the sheltered shores there was attached a thick carpet of *Spirogyra*, which gave to the water an offensive taste and, as the lake receded, was left to rot and dry in the sun. Whether or not this alga was made more abundant by the organic wastes from Ausable River and Burlington than it would have been if these sources of pollution were absent is not known. Certainly the alga did not occur in greater profusion than in other lakes which are known to be pure. During the earlier part of the summer the alga *Ulothrix* was found upon the rocks in considerable quantity. As *Spirogyra* and *Ulothrix* appeared to be the organisms which give cause for complaint, it was determined to make as comprehensive tests of the effect of the soda and sulphite wastes upon them as time and facilities would allow. The tests reported have not the finality of a detailed investigation, but they serve to show certain general facts.

EFFECT OF MILL WASTE ON ALGÆ.

EXPERIMENT 1.

The alga known as *Ulothrix* was collected from the shores on the west side of the lake and placed, with the stones to which it was attached, in pails filled with lake water. This was done on August 3, 1904, and the plants were allowed to grow until August 10, at which time they were in a healthy condition, in no case being killed or stunted by reason of their transference from the lake to the pails. The water in which the plants were growing was then treated with effluent from the sedimentation bed of the Willsboro mill, as follows: One pail left untreated for control; second pail mixed in the proportion of 1 part of waste to 25 parts of water; third pail, 1 part of waste to 100 of water; fourth pail, 1 part of waste to 1,000 of water; fifth pail, 1 part waste to 5,000 of water.

On August 16, six days after this treatment, the growth in the untreated specimen continued normal; that in the 1 to 5,000 solution appeared somewhat bleached; the 1 to 1,000 specimen was markedly damaged, while the stones in all the other pails were clean.

EXPERIMENT 2.

An experiment similar to the one above outlined was commenced upon *Spirogyra* on October 18. The plant is extremely rugged in character, and that selected for experiment was in excellent condition. Dilutions of waste were made the same as in the previous experiment.

At the end of two days the algæ in the pail containing the solution in the proportion of 1 to 25 were dead, while at the end of two weeks all the others had been killed except the specimen in the dilution of 1 to 5,000, which had been markedly bleached and was in an unhealthy condition. Those in the untreated pail were vigorous.

BACTERIA.

EFFECT OF MILL WASTES.

SAMPLES FOR TESTING.

In order to test the effect of this waste on bacteria in general and on the specific germs of disease, three samples were sent to Mr. C-E. A. Winslow, of the bacteriological department of the Massachusetts Institute of Technology, and by him were turned over to Mr. Earle B. Phelps for investigation. The report of Mr. Phelps, dated October 11, 1904, follows:

REPORT OF MR. EARL B. PHELPS.

SIR: Last August you sent to Mr. C-E. A. Winslow three small bottles of liquid marked "Effluent from sedimentation bed, soda process pulp mill," with a request that they be examined as to their germicidal properties, in order to determine the probable effect of the discharge of such a liquor into a stream. This work was turned over to me by Mr. Winslow, and I have the following report to make upon the results of my investigation upon this waste liquor. At Mr. Winslow's suggestion the following tests were made:

(1) Physical examination, determination of alkalinity, and of numbers of organisms in the samples as received.

(2) Effect of liquor on mosquitoes (*Culex*), larvæ and pupæ.

(3) Effect of liquor on the bacteria in sewage; (a) Germicidal action on the organisms of sewage which grow upon gelatine; (b) Effect on the putrefaction of sewage as measured by the "incubator test."

(4) Effect of liquor on specific disease germs; (a) *B. typhosus;* (b) *B. anthracis* (spores).

The samples as received by us differed among themselves, and we are informed by you that this is the normal variation to be expected in the liquor. I therefore carried out all the tests upon either two of the samples or upon all three of them.

Determinations.—The first sample, which I have called A, was a clear, almost colorless liquid, possessing a very faint empyreumatic odor. Plated out on algæ and allowed to develop at 37° C. for forty-eight hours, it was found to contain 10 bacteria per centimeter. It was alkaline in reaction to the amount of 3.4 per cent normal.

The second sample, B, was decidedly turbid and of a pale-yellow color; no odor. It contained 2,100 bacteria per centimeter and its alkalinity was equal to 2.8 per cent normal.

The third sample, C, was colorless and odorless and was found to contain 13 bacteria per centimeter and to have an alkalinity of 3.6 per cent normal.

Effect on mosquitoes.—In a mixture of equal parts of tap water and liquor, some larvæ and pupæ lived for eight hours, although the majority died during that period. The liquor was observed to form a heavy flocculent precipitate when mixed with the water, and no doubt carried down with it any food material which might have been present; the larvæ were seen grubbing upon this heavy precipitate in an endeavor to feed. It is very possible that they may have been simply starved out rather than

killed by any poisonous effect of the liquor. Several full-grown pupæ were placed in the undiluted liquor, in which they lived for about thirty hours. I had previously found that both larvæ and pupæ of *Culex* thrive in a fairly strong solution of uranic acetate if food be presented.

Germicidal effect on sewage bacteria.—I plated out a sample of Boston sewage and then mixed some of the sewage with varying proportions of the liquor. The tubes thus prepared, together with a control tube of sewage alone, were set aside for six hours; then they were plated out and the number of bacteria determined. This experiment was made with both A and B. It was necessary to take into account also the original number of bacteria present in the liquor, these being greatly different in the two samples. The results of this test are given in Table XXX.

TABLE XXX.—*Germicidal action of the soda-mill waste liquor upon the organism of sewage.*

Per cent of liquor by volume in mixture.	Number of bacteria.				Per cent of reduction.	
	Initial number.		Final number after 6 hours.			
Control (0).....	270,000		290,000		8a	
	A.	B.	A.	B.	A.	B.
50.....	135,000	136,000	1,400	2,400	99.0	98.2
80.....	45,000	48,000	600	1,200	98.7	97.5

a Increase.

NOTE.—The initial number under A and B is calculated from the number in the sewage itself and in the two samples of liquor, as already given.

The results here found are somewhat peculiar in that with a greater addition of liquor the percentage reduction in numbers is less. This may be explained, perhaps, by the presence of organisms in the liquor itself. These organisms doubtless can withstand the action of the liquor and multiply rapidly when that liquor is mixed with sewage. The reduction in numbers is seen to be great in any case.

The "incubator test," so called, is used to determine whether or not putrefaction will take place within the sewage or effluent under certain laboratory conditions. A determination of the "oxygen consumed" is first made on the sample. A small glass-stoppered bottle is then filled completely with the sewage, stoppered up, and placed in an incubator kept at a certain definite temperature. I used, for convenience, 37° for five days. The oxygen consumed is again determined. If nitrifactive decomposition has taken place the organic matter is thereby rendered less stable and is more readily oxidized. Hence an increase in the oxygen consumed during the incubation is an indication of putrefaction having taken place. This test was applied to a series of samples containing varying amounts of the paper-mill liquor, together with a control containing no such liquor, and the results are given in Table XXXI.

TABLE XXXI.—*Effect of soda-mill waste liquor upon the putrefaction of sewage as shown by the "incubator test."*

[Parts per million.]

Per cent of liquor in mixture.	Oxygen consumed.					
Control	A.		B.		C.	
	Initial.	Final.	Initial.	Final.	Initial.	Final.
0.....	33	50	33	50	33	50
10.....	38	39	40	41	34	36
1.....	33	57	33	52	33	55

It appears from these figures that the liquor almost entirely prevents the putrefying activity of the organisms when 10 per cent is present, but that if present in only small amounts it slightly increases the putrefaction. This result may be due to its alkaline reaction, by which it neutralizes the acid products formed and allows the organisms to work with less interference from their own by-products.

Effect on specific disease germs.—I have also tested the germicidal power of this waste liquor upon certain specific disease germs, namely, *Bacillus typhosus* and spores of *Bacillus anthracis.*

(a) *Bacillus typhosus.*

A four-day broth culture of this organism was diluted and treated with varying amounts of the liquor. At the end of six hours these cultures were plated out on agar with proper dilution and grown fifteen hours at 37° C. The results are given in Table XXXII:

TABLE XXXII.—*Germicidal action of the soda-pulp-mill waste liquor upon Bacillus typhosus.*

Per cent of liquor in mixture.	Initial number.	Final number.	
Control (0).....	34,000,000	120,000,000	
		"A."	"B."
50	17,000,000	0	0
10	31,000,000	0	0
1	34,000,000	1,300	0

The liquor is seen to have a very strong germicidal action upon *Bacillus typhosus* even in quite dilute solution.

(b) *Bacillus anthracis* (spores).

A 24-hour broth culture of this organism was heated to 80° C. for fifteen minutes to kill vegetative cells. This culture was then treated exactly as was the typhosus culture, with the results given in Table XXXIII:

TABLE XXXIII.—*Germicidal action of the soda-pulp-mill waste liquor upon Bacillus anthracis (spores).*

Per cent of liquor in mixture.	Initial number.	Final number.	
Control (0).....	9,600	460,000	
		"A."	"C."
50	4,800	0	0
10	8,000	110,000	190,000
1	9,500	125,000	200,000

These figures show that in a 50 per cent solution the *Bacillus anthracis* are all killed, but that in the greater dilution there is a considerable growth of this organism.

Conclusions.—To summarize, it appears that for some bacteria the effluents studied have marked germicidal power. Even 1 per cent is fatal to *Bacillus typhosus* in six hours. This strength of solution, however, rather favors the activity of ordinary putrefactive bacteria. In 10 per cent solution, on the other hand, putrefactive processes are checked, although *Bacillus anthracis* can still multiply. In 50 per cent effluent liquor anthrax spores are killed and over 98 per cent of common sewage bacteria are destroyed. The same solution is fatal to mosquito larvæ in a few hours and to pupæ in a day or more. Certain bacteria may live in the undiluted effluent, as shown by the fact that none of the plates made from the original sample were quite sterile. With regard to the effect of the discharge of this liquor into a stream, it is evident, of course, that the relative volume of the discharge, as compared with that of the stream, is a prime factor. In a dilution of 100 times there will be little antiseptic action, but a very considerable precipitation of the impurities of the water by the waste liquor, which precipitate will carry down with it and probably destroy a large percentage of the organisms present. I found that a sample of Boston sewage mixed with 1 per cent of the waste liquor was completely clarified. The waste might indeed be used as a precipitant for domestic sewage. In a stream this process would cause a serious accumulation of sludge in the channel if the velocity were not too great. In any case accumulations are bound to occur behind milldams and in the lower reaches of the stream. This accumulated sludge, while antiseptic at first, will doubtless lose much of its germicidal properties by diffusion and will eventually putrefy and cause a nuisance.

The effect of the effluent upon the bacillus of typhoid fever indicates that it might have a favorable effect upon a stream as regards the presence of disease germs.

Respectfully submitted.

EARLE B. PHELPS.

FISH.

The claim that fishing in Lake Champlain is not so good as in former years is apparently borne out by the facts, but the idea that this condition is caused by polluted material is erroneous. On the lake on a

still day thousands of perch were seen coming to the surface, and perch and lake bass lie off the piers in abundance. Only rarely, however, can they be induced to take the hook, though the most tempting bait is lowered before their noses. All about the sewer outlet of Burlington and up in Bouquet River even to the outlet of the sedimentation bed numerous shoals of very small fish may be seen at almost any time. Diligent inquiry among the people living along the lake on both sides failed to substantiate the startling assertions so often made in the public press concerning the enormous accumulations of dead fish along the shores. In Ausable River and in Ticonderoga Creek below the pulp mills no evidences of fish life could be found.

SAWDUST AND GROUND WOOD.

There are large accumulations of sawdust and ground wood along the shores and about the mouth of almost every Adirondack stream. Although this is probably not productive of any poisonous matter, it has its serious effects: First, it is damaging to shore property in that it presents an unsightly appearance, destroys the beaches, and renders the region in which it is deposited generally objectionable; second, it covers the spawning beds and drives fish to other localities; and, third, it is a needless waste of good material. Sawdust, if properly handled, is a marketable product and can in any case be used for fuel.

Sawdust and ground wood when turned into streams is physically objectionable, especially when water supplies are taken out below the point at which such material is deposited. In one case in the Champlain region considerable damage has been done to a filtration system by the deposits accumulated upon the beds. The evil is a growing one and must eventually receive attention.

SUMMARY.

1. Soda-pulp waste from the Champlain mills of the New York and Pennsylvania Company, situated at Willsboro, N. Y., is not perceptible in Lake Champlain beyond a maximum distance of 2,000 feet from the mouth of Bouquet River, provided that the sedimentation bed installed at Willsboro is used.

2. Sulphite-pulp waste from the mills of the J. & J. Rogers Company, situated at Ausable Forks, N. Y., is apparently perceptible in Lake Champlain for a considerable distance from the mouth of Ausable River.

3. The sewage of Burlington and Winooski River is a serious damage to that part of Lake Champlain immediately surrounding. The inhabitants of Burlington are "drinking from their own cesspool."

4. Soda waste from the mills of the Ticonderoga Pulp and Paper Company, situated at Ticonderoga, N. Y., causes a high proportion of chlorine to appear in the lake water. There is no real damage from this source.

5. The water of the broad lake is of good quality.

6. The sewage conditions as a whole are a growing menace, and if the lake is to be preserved as a water supply the entire question should be studied from interstate and international standpoints and the necessary safeguards provided.

INDEX.

Page.

Adirondack Mountains, iron mines in, opening of 11
Algæ, conditions of existence of 109
effect of mill wastes on 110–111
growth of, complaints of 9, 65, 108
Anthrax spores, effect of mill wastes on 111, 113–114
Appletree Shoal, sewage emptied near 66
water supply from 66
Argentine, Kans., water at, analysis of 38
Ausable Chasm, location and character of . 48
views in 24, 32
Ausable Forks, N. Y., location and industries of 48
Ausable Point, width of lake at 14
Ausable River, effect of sulphite-pulp wastes on 51–52
falls on, view of 48
fish in 115
industries on 48
investigation at mouth of 54–65
maps showing 54, 57, 60
origin and course of 48–49
pollution of 49–52
valley of, character of 15
water of, analysis of 52
Bacillus coli communis, occurrence of 67, 81, 83, 86, 88
tests for 82–83
Bacteria, effect of mill wastes on 111–114
Balanus miser, occurrence of 14
Bates, E. L., acknowledgments to 10
Bayonne, N. J., water at, analysis of 38
Black-ash sludge, origin and character of .. 30–35
Bleach, production of 32
Bouquet River, comparison of other water supplies and 38–39
effect of soda-mill wastes on 36–39
fish in 115
floods on, effect of 35–36
flow of 25
investigations at mouth of 41–48
maps showing 40, 42, 46
origin, course, and flow of 21–23
pollution of 22
trough over, view of 18
valley of, character of 15
views of 22
water of, analysis of 36, 37, 38
water power on 22
Bulwagga Bay, location of 16, 18

Page.

Burlington, Vt., fish near 115
investigation of lake water at, maps showing 77, 79, 84, 87
lake front at, views of 66
location of 66
sewage of 66–67
complaints of 9
damage to lake from 90
water supply of 9–10, 66
analysis of 69
intake of 66, 71–74
past history of 68–74
present condition of 74–90
investigations of 75–88
conclusions concerning 88–90, 115
Bush, C. E., acknowledgments to 10
Cedar Rapids, Iowa, water at, analysis of .. 38
Cellulose, character of 23–24
Champlain, Lake. *See* Lake Champlain.
Champlain, Samuel de, discovery of Lake Champlain by 11
Champlain Canal, opening of 11
Chipmans Point, water at, analysis of 91–92
Clinton, Iowa, water at, analysis of 38
Clintonville, N. Y., location and character of 48
Council Bluffs, Iowa, water at, analysis of .. 38
Crandall, T. H., on Burlington water supply 68, 70, 72
Crown Point, fortifications on, cost of 17
fortifications on, ruins of, view of 18
lake at, character of 16–17
width of 17
Cumberland, Md., water at, analysis of 38
Diarrhea, occurrence of 69–71, 74, 89
Dibble Mountain, location and altitude of . 17
Dodge, Kans., water at, analysis of 38
Ellis, A. H., acknowledgments to 10
El Paso, Tex., water at, analysis of 38
Emmons, Ebenezer, on Champlain Valley .. 14–16
Essex Island, water near, analysis of 63
Ethan Allen, Fort, sewage of 66, 85
Fish, destruction of, complaints of . 9, 39, 114–115
Floods, effect of, on sedimentation bed 35–36
Fossils, occurrence of 14
Four Brothers Island, water near, analyses of 20
Frederick, Fort, construction of 17
Freight on Lake Champlain, decline of 13
Geologic history of Champlain Valley 15–16
Geology of Champlain Valley 15–16

	Page.
Gull Island Reef, water at, analysis of	20
Hatch, Edward, jr., acknowledgments to	10
Hills, Joseph L., analyses by	69, 80
on Burlington water supply	68, 80
Houston, Tex., water at, analysis of	38
Indians, warfare of, along Lake Champlain	11
International Pulp Company, water power of, view of	92
Investigation, character of	19, 24
methods of	39–41, 53
Jones Point, water near, analysis of	20
Juniper Island, water near, analysis of	20, 63
Keeseville, N.Y., location and industries of	48
view at	48
water supply of	51–52
Lake Champlain, algæ in	108–111
assimilative power of	74–75
character of	16–17
complaints of pollution of	9
depth of	16, 18
description of	14–19
effect of sewage on	89–90
effect of soda-mill waste on	39–48, 102–108
conclusions concerning	47–48, 107
investigation of	41–47, 102
methods of	39–41
effect of sulphite-pulp waste on	53–65
conclusions concerning	62–65
investigations of	53
methods of	53
function of, as water supply	13–14
history and development of	11–14
investigations on, maps showing	40, 42, 46, 54, 57, 60, 77, 79, 84, 87, 101, 105
map of	14
upper end of, character of	16–17
pollution at	90–108
water at, character of	90–93
water of, analyses of	41–44 46, 55–56, 58–59, 62–63, 69, 73, 76, 78 80, 84–86, 88, 92, 94, 100, 103–104, 106
character of	19–21, 90–93
chlorine in	108
comparison of Ticonderoga Creek water and	99–100
condition of, summary of	116
width of	14, 17
Lime, percentage of, in soda-mill wastes	35
Lime, caustic, use of	30
Lime sludge, origin, character, and disposition of	30–33
Liquid effluent, second, analysis of	29
Liquid effluents, origin and character of	26–30
Los Angeles, Cal., water at, analysis of	38
McCullough, John G., acknowledgments to	10
investigation requested by	10
Maquoketa, Iowa, water at, analysis of	38
Mason, R. L. P., acknowledgments to	10
Mason City, Iowa, water of, analysis of	38
Massachusetts, lakes in, solids in	20
Michigan, Lake, water of, analysis of	38
Minneapolis, Minn., water at, analysis of	38
Moat, C. P., acknowledgments to	10
Modiola, occurrence of	14
Mosquitoes, effect of mill wastes on	111–112, 114
Moosehead Lake, Me., water of, solids in	20
Mount Vernon, Ohio, water at, analysis of	38
Mya arenaria, occurrence of	14
truncata, occurrence of	14
Natica clausa, occurrence of	14
Newell, F. H., letter of transmittal by	7
New England Water Works Association, paper read before	68
New York and Pennsylvania Company, mills of, location of	22, 33
mills of, manufacture of soda-pulp at	24–36
sedimentation bed of	33, 35, 47–48
trough of, view of	18
view of	24
wastes of, disposal of	33–36
effects of	36–40
effects of, summary of	47–48, 115
weir of, view of	32
Nichols, W. R., analyses by	69
Paine, A. G., jr., acknowledgments to	10
Pecten islandicus, occurrence of	14
Phelps, Earle B., on mill wastes and bacteria	96, 111, 114
Poplar, analysis of	34
use of	25
Population on Lake Champlain, rise and fall of	12
Postville, Iowa, water at, analysis of	38
Prescott, S. C., analysis by	72–73
Providence Island, water near, analysis of	63
Pueblo, Colo., water at, analysis of	38
Pulp, chemical, character of	23
Pulp, wood, accumulations of	38–39, 65
constituents of	23–24
Pulp mills, advantages and disadvantages of	9, 39, 47, 97
complaints concerning	9
Pulp, soda, manufacture of	24–33
manufacture of, processes of	95–96
wastes of	25–36
effect on Bouquet River from	36–39
effect on Lake Champlain from	39–48, 102–108
effect on Ticonderoga Creek from	97–102
pollution by	23–48
Pulp, sulphite, indestructibility of	50–51
manufacture of, processes of	49–50
wastes of	50–51
benefits from	52
dilution of	65
effect on Ausable River from	51–52
effect on Lake Champlain from	53–65
pollution by	49–52, 64–65
Quaker Smith Reef, water near, analysis of	20
Rangeley Lakes, Me., water of, solids in	20
Richelieu River, location and character of	18
Rockwell City, Iowa, water at, analysis of	38
Rogers, James, acknowledgments to	10
Rogers, J. & J. Co., mills of, location of	49
mills of, manufacture of sulphite pulp at	49–51
wastes of	50–51
effects of	51–65
effects of, summary of	115
Sabin, A. H., analyses by	69, 81
Sand bars, direction of	19
San Diego, Cal., water at, analysis of	38
Saranac River, valley of, character of	15
Sawdust, accumulations of	115

Page.

Sawdust, accumulations of, view of..... 48
Saxicava rugosa, occurrence of..... 14
Scalaria groenlandica, occurrence of..... 14
Schuyler Island, water near, solids in..... 68
Sedimentation bed, benefits from..... 97
character and use of..... 88
criticism of..... 47–48
effluent from, analysis of..... 31
efficiency of..... 35–36, 96–97
floods on..... 35–36
Sedgwick, W. T., investigations and report by..... 68–74, 89
Seeley, H. M., analyses by..... 69, 80
Seward, W. H., report to..... 14
Sewage, effects of, conclusions concerning. 116
effect of mill wastes on..... 112–113
pollution from..... 66–90
Sioux Falls, S. Dak., water at, analysis of.. 38
Soda, caustic, recovery of..... 28
use of..... 25, 29
Soda-mill waste. *See* Pulp, soda, wastes of.
Sodium chloride, occurrence of..... 108
Spirogyra, effect of mill wastes on..... 110–111
Split Rock, water near, analysis of..... 20
Spruce, use of..... 49
Stearns, F. P., on Burlington water supply. 70
Stone, B. H., acknowledgments to..... 10
on Bacillus coli communis..... 82
Sulphite-pulp waste. (*See* Pulp, sulphite, wastes of.)
Sulphur, use of..... 49
Tellina groenlandica, occurrence of..... 14
Terebratula psittacea, occurrence of..... 14
Ticonderoga, N. Y., sewage of..... 91, 93–94
view at..... 90
Ticonderoga Creek, character of..... 93
effect of soda-mill wastes on..... 97–102
fish in..... 115
investigations at mouth of..... 97–107
conclusions concerning..... 107–108
maps showing..... 101, 105
lime in..... 98
soda in..... 95–96
water of, analysis of..... 93–94, 98, 100
comparison of lake water and..... 99–100

Page.

Ticonderoga Pulp and Paper Co., mills of, location of..... 94, 97
mills of, manufacture at, processes of.. 90–91
view of..... 96
sedimentation bed of, view of..... 92
wastes of, effects of..... 90, 94, 97–108
effects of, conclusions concerning..... 107–108, 116
water power of, view of..... 90
Topeka, Kans., water at, analysis of..... 38
Trembleau Point, location of..... 18
Tritonium anglicum, occurrence of..... 14
fornicatum, occurrence of..... 14
Typhoid bacillus, effect of mill wastes on. 111, 113–114
Typhoid fever, occurrence of..... 69–71, 74, 89
Ulothrix, effect of mill wastes on..... 110
Water of lake, analyses of..... 20
character of..... 19–21
Water used in soda-pulp manufacture, amount of..... 25
Water supplies, public, analyses of..... 38
Water supply, function of lake as..... 13–14
Waterloo, Iowa, water at, analysis of..... 38
West Milwaukee, Wis., water at, analysis of. 38
Whitehall, N. Y., sewage from..... 91
Willsboro, N. Y., view at..... 22
Willsboro Bay, character of..... 18
water at, analysis of..... 20
Winnepesaukee Lake, N. H., water of, solids in..... 20
Winchester, Va., water at, analysis of..... 38
Winooski, N. Y., sewage of..... 66, 85–86
Winooski River, character of..... 66
pollution of..... 66, 85
sewage from, effects of..... 85–88
summary concerning..... 115
Winslow, C.-E. A., samples sent to..... 111
Witthaus, R. A., analyses by..... 69, 81
Wood, extractives of, character of..... 24
Wood, ground, accumulations of..... 115
accumulations of, view of..... 48
Wood Creek, location of..... 16
Yuma, Ariz., water at, analysis of..... 38

PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Water-supply and Irrigation Paper No. 121.]

The publications of the United States Geological Survey consist of (1) Annual Reports; (2) Monographs; (3) Professional Papers; (4) Bulletins; (5) Mineral Resources; (6) Water-Supply and Irrigation Papers; (7) Topographic Atlas of the United States, folios and separate sheets thereof; (8) Geologic Atlas of the United States, folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

The Professional Papers, Bulletins, and Water-Supply Papers treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous; H, Forestry; I, Irrigation; J, Water storage; K, Pumping water; L, Quality of water; M, General hydrographic investigations; N, Water power; O, Underground waters; P, Hydrographic progress reports.

The following Water-Supply Papers are out of stock, and can no longer be supplied: Nos. 1-16, 19, 20, 22, 29-34, 36, 39, 40, 43, 46, 57-65, 75. Complete lists of papers relating to water supply and allied subjects follow. (PP=Professional Paper; B=Bulletin; WS=Water-Supply Paper.)

SERIES L—QUALITY OF WATER.

WS 3. Sewage irrigation, by G. W. Rafter. 1897. 100 pp., 4 pls.
WS 22. Sewage irrigation, Pt. II, by G. W. Rafter. 1899. 100 pp., 7 pls.
WS 72. Sewage pollution near New York City, by M. O. Leighton. 1902. 75 pp., 8 pls.
WS 76. Flow of rivers near New York City, by H. A. Pressey. 1903. 108 pp., 18 pls.
WS 79. Normal and polluted waters in northeastern United States, by M. O. Leighton. 1903. 192 pp., 15 pls.
WS 103. Review of the laws forbidding pollution of inland waters in the United States, by E. B. Goodell. 1904. 120 pp.
WS 108. Quality of water in the Susquehanna River drainage basin, by M. O. Leighton, with an introductory chapter on physiographic features, by G B. Hollister. 1904. 76 pp., 4 pls.
WS 113. Strawboard and oil wastes, by R. L. Sackett and Isaiah Bowman. 1905. 52 pp., 4 pls.
WS 121. Preliminary report on the pollution of Lake Champlain, by M. O. Leighton. 1905. 119 pp., 13 pls.

Correspondence should be addressed to

THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, D. C.

LIBRARY CATALOGUE SLIPS.

[Mount each slip upon a separate card, placing the subject at the top of the second slip. The name of the series should not be repeated on the series card, but the additional numbers should be added, as received, to the first entry.]

Author.

Leighton, Marshall Ora, 1874—

. . . Preliminary report on the pollution of Lake Champlain, by Marshall Ora Leighton. Washington, Gov't print. off., 1905.

119, iii p. illus., XIII pl. (incl. map). 23cm. (U. S. Geological survey. Water-supply and irrigation paper no. 121.)

Subject series: L, Quality of water, 9.

1. Water, Pollution of. 2. Lake Champlain.

Subject.

Leighton, Marshall Ora, 1874—

. . . Preliminary report on the pollution of Lake Champlain, by Marshall Ora Leighton. Washington, Gov't print. off., 1905.

119, iii p. illus., XIII pl. (incl. map). 23cm. (U. S. Geological survey. Water-supply and irrigation paper no. 121.)

Subject series: L, Quality of water, 9.

1. Water, Pollution of. 2. Lake Champlain.

Series.

U. S. Geological survey.

Water-supply and irrigation papers.

no. 121. Leighton, M. O. Preliminary report on the pollution of Lake Champlain. 1905.

Reference.

U. S. Dept. of the Interior.

see also

U. S. Geological survey.

Water-Supply and Irrigation Paper No. 122 Series O, Underground Waters, 35

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

Relation of the Law to Underground Waters

BY

DOUGLAS WILSON JOHNSON

WASHINGTON
GOVERNMENT PRINTING OFFICE
1905

CONTENTS.

	Page.
LETTER OF TRANSMITTAL	5
INTRODUCTION	7
Abbreviations used	7
CHAPTER I. Common-law rules concerning underground waters	9
Definition of underground waters	9
Classification of underground waters	9
Underground waters of the first class	10
What constitutes underground waters of the first class	10
Laws relating to underground waters of the first class	11
Underground waters of the second class	12
Laws relating to underground waters of the second class	12
General principles	12
Interference with wells	14
Interference with springs	17
Interference with streams	18
Injury to land	19
Damming of underground waters	21
Disposal of intercepted underground waters	21
Artificial production of percolation	22
Artificially increased percolation	23
Pollution of underground waters	25
Effect of motive	28
Effect of grant or agreement	30
Effect of prescription	31
Summary and conclusions	32
CHAPTER II. Legislative acts affecting underground waters	39
Introduction	39
California	39
Colorado	40
Idaho	41
Michigan	42
Nebraska	42
Nevada	43
New Jersey	43
New Mexico	44
Oklahoma	44
Oregon	44
South Dakota	45
Utah	48
Washington	48
Wisconsin	49
Wyoming	49
INDEX	51

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
HYDROGRAPHIC BRANCH,
Washington, D. C., February 23, 1905.

SIR: I have the honor to transmit herewith a manuscript entitled "Relation of the Law to Underground Waters," prepared by Douglas Wilson Johnson at the request of Mr. M. L. Fuller, in charge of the eastern section of the division of hydrology, and recommend that it be published as a water-supply and irrigation paper.

This manuscript, which is the first comprehensive paper prepared in this country on the relation of the law to underground waters, was compiled to meet a considerable and ever-increasing demand for information as to the application of the law to this subject. It is especially pertinent at this time, when active efforts are being made in several States to enact laws governing the use of underground waters which shall take account of the recent advances in the science of hydrology and the present knowledge of the occurrence and movements of such waters.

Very respectfully,

F. H. NEWELL, *Chief Engineer.*

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

RELATION OF THE LAW TO UNDERGROUND WATERS.

By Douglas Wilson Johnson.

INTRODUCTION.

The following pages represent an attempt to outline the main features of the laws respecting underground waters, with the object of giving to the owner of such waters some idea of his rights and obligations concerning them. It is needless to say that the report is in no sense a legal treatise, but rather an endeavor to collect and arrange such legal decisions as will serve to show the relation of the law to problems which are essentially geological in character. In summing up the general features of this law, I have recorded some observations which present themselves to the student of geology.

Throughout the preparation of the paper I have received much help from such authoritative works as John M. Gould's treatise on the "Law of Waters," Pomeroy's treatise on "Water Rights," the section of the American and English Encyclopædia of Law dealing with "Underground Waters," and the Lawyer's Reports Annotated. The original reports of all the cases here cited, as well as of many others, have been consulted in the endeavor to ascertain just what were the critical points upon which each was decided. I am indebted to Prof. John C. Gray, of the Harvard Law School, and Mr. George Albert Walker, of the Boston bar, for valuable criticism.

ABBREVIATIONS USED.

Allen (Mass.)=Allen's Massachusetts Reports.
Am. Dec.=American Decisions.
Am. Law Reg.=American Law Register.
App. Cas.=Appeal Cases, English Law Reports.
B. & S.=Best and Smith's English Queen's Bench Reports.
Barb.=Barbour's Supreme Court Reports, New York.
Beav.=Beavan's English Rolls Court Reports.
Cal.=California Reports.
Cent. Rep.=Central Reporter.
Ch. Div.=Chancery Division, English Law Reports.
Conn.=Connecticut Reports.

Ct. of Cl.=Court of Claims, United States.

Cush. (Mass.)=Cushing's Massachusetts Reports.

El. & Bl.=Ellis and Blackburn's English Queen's Bench Reports.

El. & El.=Ellis and Ellis's English Queen's Bench Reports.

Enc.=American and English Encyclopædia of Law, vol. 27, "Underground Waters," pp. 423–444.

Exch.=Exchequer Reports (Welsby, Hurlstone, and Gordon).

Gould="A Treatise on the Law of Waters," third edition, by John M. Gould, Ph. D., Chicago, 1900.

H. &. N.=Hurlstone and Norman's English Exchequer Reports.

H. L. Cas.=House of Lords' Cases.

Hun=Hun's New York Supreme Court Reports.

Ill.=Illinois Reports.

Ind.=Indiana Reports.

Iowa=Iowa Reports.

Jones' Eq.=Jones's North Carolina Equity Reports.

Ky.=Kentucky Reports.

L.=Laws (legislative acts of States and Territories).

L. R. A.=Lawyer's Reports Annotated, Rochester, N. Y. (Lawyers' Cooperative Publishing Company).

L. R. C. P.=English Law Reports, Common Pleas.

L. R. Ch.=English Law Reports, Chancery, Appeal Cases.

L. R. H. L.=English Law Reports, English and Irish Appeal Cases.

L. R. P. C.=English Law Reports, Privy Council, Appeal Cases.

L. T. N. S.=Law Times Reports, New Series.

M. & W.=Meeson and Welsby's English Exchequer Reports.

Mass.=Massachusetts Reports.

Me.=Maine Reports.

Mich.=Michigan Reports.

N. Car.=North Carolina Reports.

N. H.=New Hampshire Reports.

N. Y.=New York Reports.

Nev.=Nevada Reports.

Ohio St.=Ohio State Reports.

Pac. Rep.=Pacific Reporter.

Penn. St.=Pennsylvania State Reports.

Pick.=Pickering's Massachusetts Reports.

Pomeroy="A Treatise on the Law of Water Rights," by John Norton Pomeroy, LL. D., and Henry Campbell Black, M. A., St. Paul, 1893.

Vt.=Vermont Reports.

CHAPTER I.

COMMON-LAW RULES CONCERNING UNDERGROUND WATERS.

Of the water which falls upon the earth in the form of rain one portion suffers evaporation, a second portion escapes by direct run-off into surface streams, while a third portion sinks into the ground. The second portion, or that which escapes into surface streams, may find its way directly to the sea, with some loss by evaporation; or it may happen that an appreciable portion of this water will later sink below the surface and pursue for some time a subterranean course. The third portion, or that which at first passes directly into the ground, may later emerge to join surface streams, or may find its way to the sea without ever reappearing at the surface. During the course of its journey underground, water may collect into more or less well-defined subterranean channels, or may pass through the general mass of porous earth by slow percolation.

DEFINITION OF UNDERGROUND WATERS.

It will be seen, then, that underground waters comprise all waters which are for the time being below the surface of the ground, whether they have reached their present position by penetrating the ground directly after the fall of rain, or by escape from such surface bodies of water as springs, swamps, lakes, rivers, etc.; whether they are confined to definite channels, or are dissipated throughout the mass of more or less porous ground; and whether they are ultimately to reach the sea without reappearing at the surface, or are soon to emerge as well-defined streams or numerous widely distributed springs.

CLASSIFICATION OF UNDERGROUND WATERS.

While recognizing the broad definition of underground waters given above, the law divides such waters into two distinct classes, and provides for each a different rule. This division is based on the method of transmission underground—whether in definite channels or by general percolation. It is evident that in many cases it would be impossible to know whether or not such underground transmission were in definite channels; and hence the law provides that where doubt exists the presumption shall be in favor of the ordinary percolation of water through the ground. Thus limited the law recog-

nizes the two following classes of underground waters: (1) Underground currents of water flowing in defined and known channels; (2) water passing through the ground beneath the surface, either without definite channels or in courses which are unknown.

UNDERGROUND WATERS OF THE FIRST CLASS.

(Underground Waters Flowing in Defined and Known Channels.)

WHAT CONSTITUTES UNDERGROUND WATERS OF THE FIRST CLASS.

The meaning of "defined and known" as here used is thus explained by Gould (558): "In this connection, 'defined' means a contracted and bounded channel, though the course of the stream may be undefined by human knowledge, and 'known,' which is not here synonymous with 'visible,' refers to knowledge by reasonable inference." When the water flows in an underground channel which could be ascertained only by excavations, such a channel is not considered as "known."

In order to be certain that a given subterranean flow comes within the scope of this class of underground waters, one must be able to show, without opening the ground by excavation, that the water flows in a definite channel. For example, it is sufficient for this purpose if one can show that a continuous stream channel exists, and that the water which disappears beneath sand and gravel in the bed of this channel at one point reappears farther downstream. This is often the case with streams in arid regions, whose waters appear at the surface only at occasional points along a channel which can be readily and continuously traced. In the case of Case *v.* Hoffman (L. R. A. 20, p. 40) it was held that "The flowing of water upon and beneath the surface of lands between a natural lake * * * and a creek into which they discharge constitutes a watercourse where the flow is all in the same direction and a part of the way along a distinct and plainly marked channel, although for some of the distance it spreads over wide reaches of marsh and swamp lands, and percolates the soil in many and most places between the lake and the creek."

If a stream flows into a sinkhole in a definite direction, pursues for a short space a subterranean course, and then emerges on the surface again, it is considered to have a definite and known channel. Even where a large stream pursues a subterranean course for a great distance, it comes within this class if it is shown to be a watercourse in the proper sense of the term. It has also been held that a subterranean stream has a well-defined channel where its course is marked by certain vegetation which would grow nowhere except above such subterranean stream. It would seem that the presence of sinkholes or depressions, the structural relations of hard and easily soluble

rocks, and other geological factors might often be of great importance in helping to establish the existence and direction of subterranean channels. And while it is not essential that the exact course of a subterranean channel be known in order to establish its existence, a knowledge of that course forms an important addition to the evidence.

It is not sufficient to show that a certain portion of water passes underground from one place to another, since that water, even though it travel in a definite direction, may reach its destination either by percolation through the more or less porous ground or by passage through definite channels. Thus, in a case where the flow of water from a spring was stopped when the water was drained out of a natural basin on higher ground, it was held that the mere fact that the spring was supplied from the basin was insufficient to show that the water flowed from basin to spring in a well-defined channel. In like manner it is probable that the transmission of coloring matter from one point to another by underground water would hardly be regarded as evidence of the existence of a definite channel, although the transmission of particles of material size, such as fragments of wood, might be considered more significant.

Where there is nothing to show that the waters in their subterranean courses are confined to definite and known channels, they are presumed to be transmitted by ordinary percolations through the ground, and so to belong to the second of the two classes of underground waters, as defined above.

LAWS RELATING TO UNDERGROUND WATERS OF THE FIRST CLASS.

In the conception of the law all those underground waters which have a definite and known channel are to be dealt with as if they were surface streams, and no distinction is made between such subterranean and surface waters because of their location. Accordingly, the laws applicable to this first class of underground waters are the same as those which apply to streams on the surface of the ground.

It is beyond the limits of this paper to enter into a discussion of the relations of the law to surface waters, but a few of the general principles upon which that law rests may be here referred to in order that the rules governing the use of underground waters of the second class may be better appreciated. Perhaps the most fundamental distinction is that the law recognizes only certain rights in the waters of surface streams (including, as we have seen, underground streams with definite and known channels), whereas it admits absolute ownership in subterranean percolating waters. The right in the waters of surface streams is, in general, the right to have the water flow through one's land in its natural state, through its accustomed channel, and without material diminution in quantity or deterioration in quality. From this it follows that, in general, one may not

consume all the water of a stream, although he may appropriate a reasonable portion for his use, provided this right is exercised with due regard to the rights of other proprietors above and below him. He may, however, consume what water is required for necessary uses, even if he renders the stream dry. He may not divert a stream so as to cause it to flow onto the land of his neighbor below in a new channel, although he may divert the stream on his own land, provided he return it to its accustomed channel without material loss before it leaves his property. He may not build a dam which will force the water back upon the land of his neighbor above.

While this is the general attitude of the law toward surface streams and underground waters of the first class, there are many exceptions. Thus, in a Massachusetts decision, it has been held that the proprietor who first builds a dam for reasonable purposes has a right to maintain it, even though it forces the water back upon the land of his neighbor upstream to such an extent as to prevent the latter from having sufficient fall to erect a mill on his land, while his downstream neighbor would not be allowed to build a dam which would raise the water so far as to stop the wheel of the first proprietor's mill. Such a right is generally given by special mill acts. This rule has been repudiated in certain other States, or else made conditional on certain other legal rights. (Pomeroy, pp. 13–15.)

The greatest exceptions, however, are to be found in the Pacific and Rocky Mountain States, where the needs of mining, customs arising in mining camps, etc., have led to the establishment of the law of "prior appropriation," by which the one who first appropriates a stream is entitled to divert, use, and consume such quantity of water from the stream as is necessary for his mining operations; and he becomes absolute owner of such water as is thus appropriated. This doctrine has been extended to all other beneficial purposes for which water is essential, such as milling, manufacturing, agriculture, irrigation, and municipal purposes. (Pomeroy, pp. 19–20; Gould, p. 451 et seq.)

UNDERGROUND WATERS OF THE SECOND CLASS.

(Water passing through the ground below the surface, either without a definite channel or in courses which are unknown.)

LAWS RELATING TO UNDERGROUND WATERS OF THE SECOND CLASS.

GENERAL PRINCIPLES.

The relation of the law to underground waters of the second class, or underground waters proper, constitutes the subject of this paper. It is to be remarked at the outset that the mutual rights and obligations of neighboring proprietors regarding surface streams (includ-

ing the first class of underground waters), which have been briefly referred to above, have no application to waters of this second class, which are, or must be presumed to be, ordinary percolations through the general mass of more or less porous ground. The fundamental principle upon which the laws regulating the use of these waters are based is this: That such percolating subterranean waters are a part of the land itself, and belong absolutely to the proprietor within whose territory they are. The land belongs to the owner, whether it be solid rock, porous ground, entirely earthy matter, or part soil and part water. The percolating waters within his territory are as truly his absolute property as are the rocks, ores, or minerals. Consequently he may take and use such waters as he pleases, although such use may cause damage to his neighbor.

From this it follows that one may withdraw from his soil all the percolating water he desires; and since it is manifestly impossible to say how much of such water was originally within the limits of his own territory, how much comes into his territory from that of his neighbors, or how much passes from his own territory into that of his neighbors, it is held that he may completely abstract all such waters from his own soil, even though in so doing he also abstracts the water from the soil of neighboring proprietors. In like manner, one may obstruct or interfere with the natural flow of underground waters of this class or change the course of such flow in any way he may choose.

There are several conditions which have resulted in the development of such a body of law. The courses of such waters as are embraced in this class being "indefinite and unknown," it has been believed that any other rule would hold a man responsible for the preservation of rights which he could not appreciate until after such rights had been violated. Not until his own well was completed could he know that it would abstract the water from his neighbor's well. Not until his own mine excavation was made could he tell that farming land miles away would be drained of its water. "One can hardly have rights upon another's land which are imperceptible."

It has also been pointed out (Tindal, C. J., in Acton *v.* Blundell, 12 M. & W., p. 350) that no one knows what changes these underground waters undergo; that perhaps only a day ago the course taken by such waters became what it is to-day. The sinking of any well may completely alter the direction of percolation over a given area; and the proprietor can not be held responsible for such changes as may benefit or damage his neighbor, but concerning which neither of them can have any knowledge until after the change is effected.

Any other rule, it is argued, would place an unbearable responsibility upon the proprietor, for in the proper use of one's own land it has happened that the waters have been drained from land several

miles away. The ordinary work of mining may so drain the water from the soil that destruction of crops, failure of streams, and even cave-ins will result at great distances from the mine. To hold the proprietor responsible for such unforeseen results of his legitimate pursuits would necessarily greatly interfere with beneficial occupations of various kinds. Such is the idea expressed by Lewis, C. J., when he says: "No man could dig a cellar or a well, or build a house on his own land, because these operations necessarily interrupt the filtrations through the earth. Nor could he cut down the forest and clear his land for the purposes of husbandry, because the evaporation which would be caused by exposing the soil to the sun and air would inevitably diminish, to some extent, the supply of water which would otherwise filter through it. He could not even turn a furrow for agricultural purposes, because this would partially produce the same result." (Wheatley *v.* Baugh, 25 Penn. St., p. 532.)

This whole matter has been summed up by one authority in the following words: "The law recognizes no correlative rights in respect to underground waters percolating, oozing, or filtrating through the earth, and this mainly from considerations of public policy—(1) Because the existence, origin, movement, and course of such waters, and the causes which govern and direct their movements are so secret, occult, and concealed that an attempt to administer any set of legal rules in respect to them would be involved in hopeless uncertainty, and would be, therefore, practically impossible. (2) Because any such recognition of correlative rights would interfere, to the material detriment of the Commonwealth, with drainage and agriculture, mining, the construction of highways and railroads, with sanitary regulations, building, and the general progress of improvement in works of embellishment and utility." (Brinkerhoff, J., in Frazier *v.* Brown, 12 Ohio St., p. 311.)

With the above brief reference to the general principles upon which the law relative to underground waters of the second class is based, attention will now be given to the application of this law to more concrete cases, exceptions to the general rules being noted, and the opinions in accordance with which typical cases have been decided quoted to such an extent as may serve to make the matter clear.

Throughout the following pages it should be borne in mind that "subterranean" or "underground" waters, as here used, refers always to the second class of underground waters—those which are, or must be presumed to be, the result of ordinary percolation through the general mass of the ground.

INTERFERENCE WITH WELLS.

It is known that where one well has been successfully supplying water for a time, and then a second well is driven in greater or less

proximity to the first, the result may be to diminish the supply of water available from the first well, or even to stop that supply entirely. This matter of "well interference" has received considerable attention from students of the problem, and it is known that the closeness with which wells may be placed without expecting serious interference depends upon several factors, among which is the manner of their disposition with regard to the direction of the movement of underground waters.

The right of a proprietor to interfere with the supply of his neighbor's well by driving a well on his own land is upheld by an almost unbroken line of legal authority. The only redress which the other has is to sink his well deeper, and the geological conditions may be such that even this will afford him no relief. A proprietor has a perfect right to dig his well and by means of it to draw off all the water from his own land which would otherwise pass to his neighbor, and also to draw off all the water coming from his neighbor's land, even if the result be to make the neighbor's well entirely dry. Or a proprietor may interfere with his neighbor's well by any other use of his own property, as by digging ditches, excavating mines or quarries, or obstructing in any way the natural flow of underground waters.

Thus, in a case where a mill was run by water raised from a well, and the sinking of a coal pit half a mile distant drew off the supply of water from the well, it was held that the damage to the mill owner was not a legal injury, and that there was no redress for him at law. (Acton *v.* Blundell, 12 M. & W., p. 324.) In like manner in a case where the construction of a sewer or drain by one party prevented water from flowing to the well of another and abstracted from the well water which had already found its way there, it was held that the party whose well was thus damaged had no legal redress. (New River Co. *v.* Johnson, 2 El. & El., pp. 434–446.) "It makes no difference whether the damage arise by the water percolating away, so that it ceases to flow along channels through which it previously found its way to the spring or well, or whether, having found its way to the spring or well, it ceases to be retained there." (Ballacorkish Mining Co. *v.* Dumball, 29 L. T. N. S., p. 659.)

A notable exception to the above rule is presented by certain New Hampshire cases, where it has been held that a proprietor must make such use of his land as is reasonable if he wishes to escape liability for damage caused to his neighbor's well. The court has expressed its opinion in one such case, as follows: "We do not think it follows * * * that a landowner has the full and unlimited ownership and the absolute and unqualified right of control of all water in or upon his land not gathered into natural watercourses; for the nonexistence of an absolute right does not conclusively disprove the existence of a qualified right. * * * Any interference by one landowner, with

the natural drainage, injurious to land of another and not reasonable is unjustifiable." (Bartlett, J., in Bassett *v.* Salisbury Mfg. Co., 43 N. H., pp. 573–574, 577; 82 Am. Dec., pp. 180, 185.) This principle, that the absolute ownership of percolating waters is to be qualified by requiring a reasonable use of such waters, has been adhered to in other cases. Thus in an Iowa case (Willis *v.* Perry, see L. R. A. 26, p. 124), a city made several wells and pumped much water from them, thereby depriving a woman of water which she was accustomed to secure from her well. The city was held liable for damages on the ground that its use of the water was not reasonable. It was also held that the reasonableness of the use did not depend upon the city's needs or wants, but should be determined in view of the number of well owners and their respective wants.

A second exception to the rule is formed by an important California case (Katz *v.* Walkinshaw, 141 Cal., p. 116), referred to in more detail under the heading "Injury to land" (pp. 20–21), where it was held that the owner of one artesian well had no right to withdraw percolating water for the purpose of carrying it to distant lands for sale when such action decreased the supply of his neighbor's well to the irreparable injury of the latter. This decision will probably form a precedent in other irrigation States where artesian water is necessary for agricultural purposes.

Another apparent exception to the general rule is to be found in those cases where a corporation or similar body, having secured control of certain land, makes such use of that land as to damage the well of a neighboring landowner, the corporation being required to pay damages in such cases. This apparent exception is to be reconciled on the ground that the corporation does not secure absolute ownership of the land, but merely purchases certain rights in that land, or else is required by the empowering statute to pay all damages resulting to property not its own. Thus, in a case where excavations by a railroad company within its right of way resulted in damage to the well of a neighboring proprietor the company was held liable for the damage, on the ground that it did not own the land, but had only acquired a special right in the land on the condition of paying all damages which might be thereby occasioned to others. (Parker *v.* Boston and Maine R. R., 3 Cush. (Mass.), pp. 109, 114.) In a case where a corporation was sinking a ditch and well and erecting a pump to get water for its customers, on land held by a private party in fee but taken by the corporation under a statute, and it was shown that the result would be to injure the water rights on adjoining land owned by the same private party, an injunction was granted against the corporation (Hart *v.* Jamaica Pond Aqueduct Co., 133 Mass., p. 488); and where a town constructed a sewer upon land taken for that purpose, thereby draining wells fed by percolation through soil on

land not taken and not adjoining land taken, it was held liable for the damage on the ground that it was not owner of the land. (Trowbridge *v.* Brookline, 144 Mass., pp. 139, 141–142.)

On the other hand, when it is considered that the corporation or similar body has become absolute owner of the land, the usual rule applies, and no damages can be recovered in case a well is injured by the use to which such corporation may choose to put its land. Thus it has been held that a city is not liable for damage resulting from the construction of a sewer. (Elster *v.* Springfield, 49 Ohio St., p. 82 et seq.) Where the water was wholly abstracted from a well as a result of the construction of the Washington water tunnel, authorized by an act of Congress, it was held that the damage was not a legal injury, since the United States had a clear title to the property. (Alexander *v.* U. S., 25 Ct. Cls., pp. 87–97.)

A railroad company was not held responsible for injury to a spring in a case where it had acquired the "right of way over and through the land for all purposes connected with the construction, use, and occupation of its railway." (Hougan *v.* Milwaukee and St. Paul R. R. Co., 35 Iowa, p. 558.) It has been held that a railroad company, for the purpose of constructing its road, has the same right to excavate within the limits of its right of way that a private individual has to dig upon his land for any purpose, and that one whose well is rendered dry as a result of such excavation can have no legal redress. (New Albany and Salem R. R. Co. *v.* Peterson, 14 Ind., 112, 114; 77 Am. Dec., pp. 60, 62.)

In general, then, the rule holds that one who actually owns land may make such use of that land as he may desire, whether such use is reasonable or not being generally held immaterial, and that any damage which such use may cause to a neighbor's well is not a legal injury.

INTERFERENCE WITH SPRINGS.

The rules of law applicable to interference with wells apply in general with equal force to interference with springs. It is usually held that a proprietor may make such use of his land as he desires, although that use may cause the water in his neighbor's spring to diminish or wholly disappear. Thus, in a case where large springs on a landowner's property were destroyed by excavations made by a metropolitan board of works for a sewer, it was held that no damages could be collected. (Regina *v.* Metropolitan Board of Works, 3 B. & S., p. 708.) Where a spring was fed solely from percolating waters from a swamp on wet land around it, and not by any running stream, it was held that no damages could be recovered against one who diverted the waters by means of a tunnel and ditch constructed

on his own land. (So. Pac. R. R. Co. *v.* Dufour, 95 Cal., p. 615; 30 Pac. Rep., p. 783.)

In a like manner it has been held in a Vermont case that "a grant of a spring does not by implication convey percolating water before it reaches the spring." (Wheelock *v.* Jacobs, 70 Vt., p. 162.) A spring destroyed by mining operations is not a subject of legal redress in case the ground itself is properly supported. (Gumbert *v.* Kilgore, 6 Cent. Rep., p. 406.) If the ground itself is improperly supported, however, and a spring is injured in consequence, damages may be collected. In general, also, a city is not responsible because a sewer constructed by it drains away the percolating waters which formerly supplied a spring. (Elster *v.* Springfield, 49 Ohio St., p. 82.)

But there are exceptions to the above general ruling of the courts. It has been held, for instance, that "where a stream, from time immemorial, has flowed through plaintiff's land in a perceptible current and in a well-defined channel, his right to have such flow continued is not affected by the fact that the source of the stream is a spring on defendant's land." (Pomeroy, p. 176; Chauvet *v.* Hill, 93 Cal., pp. 407–410; 28 Pac. Rep., pp. 1066–1067.)

The question of reasonableness of use has been emphasized in some cases, as, for instance, where a person dug a trench and placed a tile pipe in such manner as to abstract percolating water which supplied a spring and to conduct it into a sewer. It was held that the person had no right to collect or divert percolating water for the sole purpose of wasting it. (Stillwater Water Co. *v.* Farmer, see L. R. A. 60, p. 875.) "Even a railroad corporation armed by law with the eminent domain, and having power to take private property for the construction of its road, is answerable to the owner of a spring for destroying it, although its destruction be caused by excavations on the land of an adjacent proprietor." (Lewis, C. J., in Wheatley *v.* Baugh, 25 Penn. St., p 533.) As in the case of well interference, discussed above, this last may be only an apparent exception to the rule, and in general is to be reconciled on the ground that the railroad company is not absolute owner of the land, but merely acquires certain rights therein, or is required by statute to pay compensating damages.

INTERFERENCE WITH STREAMS.

According to the law of surface waters a landowner is entitled to have a surface stream flow through his land in its natural condition without material diminution in quantity. But such streams are often fed largely, either directly or indirectly, by percolating waters. This brings about an inevitable conflict between the laws of surface and subterranean waters, for according to the one a proprietor can not do anything which will diminish the volume of the stream flowing through his neighbor's land, while according to the other he has a

perfect right to the percolating waters which supply that stream, even though by using such waters he may diminish the volume of the stream. Conflicting decisions have been the result of such a condition.

The decisions of many authorities are on the side of the application of the laws relating to subterranean waters, according to which the one who suffers as a result of the diminished volume of the stream has no recourse against the one who caused the damage. Thus, in a case where a mill which had been propelled for more than sixty years by a stream was retarded because the stream was diminished in volume as a result of the sinking of a well which abstracted a great amount of the percolating waters which fed the stream, it was held that the damage was not a legal injury. (Chasemore *v.* Richards, 7 H. L. Cas., p. 349; 2 H. & N., p. 168; 5 H. & N., p. 982.) It has likewise been held in California that the fact that a party is entitled to the water of a stream which is fed by a spring can not prevent the owner of the land from digging ditches for a useful purpose and thereby diverting the percolating waters which supply the spring. (So. Pac. R. R. Co. *v.* Dufour, 95 Cal., pp. 619–620.)

On the contrary, in another case where parties sunk a well on their own property, thus preventing water from percolating in its natural course into a stream upon which another's mills were situated, resulting in damage to the running of the mills, it was held that the parties causing the damage were liable for it. (Dickinson *v.* Grand Junction Canal Co., 7 Exch., p. 282.) So also it has been held that "the draining of the underground sources of a surface stream by pumping water from wells to supply a city reservoir renders the city liable to the owner of the land through which the stream naturally flows, although the city is the owner of the land on which the wells are located." (Smith *v.* Brooklyn, 160 N. Y., p. 357.) In another case similar to the above, where the defense was made that the defendant had only intercepted underground waters before they reached the stream, the defense was held to be insufficient. In Nevada it has been held that where a stream is fed by springs, but the water in passing from such springs to the stream takes a course underground which is not well understood or defined, one can not lawfully cause damage to a prior appropriator on the stream by gaining control of the water from the springs on the ground of a right to take subterranean and percolating waters. (Strait *v.* Brown, 16 Nev., pp. 317–324.)

INJURY TO LAND.

The damage caused by withdrawing subterranean waters is not wholly restricted to interference with the natural conditions of wells, springs, and streams. It may happen that the withdrawal of such waters will result in a sinking or caving in of a neighbor's land or in the destruction of his crops. On the general principle that a man is

absolute owner of the subterranean percolations within his territory and may do as he pleases with them, and because it is held that a man has no legal right to the support of underground water, it has been decided that where a landowner withdraws so much of such water as to cause a subsidence of the land in his neighbor's territory or an injury to his crops, he is not responsible for the damage. So, also, while a man entitled to take minerals from a land is required to leave proper support for the surface he may drain the subterranean water from the ground, even if that results in a subsidence of the surface. (See Gould, p. 565 and subjoined references.)

On the other hand, cases have been decided in the opposite way—as, for example, a certain New York case where it has been held that "The draining of land of a private proprietor by city pumping works which exhaust from all the region thereabouts the natural supply of underground or subsurface water and thus prevent the raising upon it of crops to which the land was and is peculiarly adapted, or destroy such crops after they are grown or partly grown, renders the city liable to him for the damages which he sustains and entitles him to an injunction against a continuance of the wrong." (Forbell *v.* N. Y., 164 N. Y., p. 522.) The statute of incorporation may hold a company responsible for damages in such cases.

A very important case in this connection is that of Katz *v.* Walkinshaw, decided by a California court in 1903. Parties owning land on which were growing trees, shrubs, etc., which were irrigated by percolating artesian water, brought suit to restrain another landowner from withdrawing such percolating artesian water for the purpose of conveying it to distant lands for sale, on the ground that such action diminished the water supply, to the irreparable injury of the trees, shrubs, etc. It was held that the usual rule of common law on the subject of such percolations was not to be regarded as any part of the law of California, where the arid climate brought about conditions totally different from those existing where the rule in question first sprang up. Consequently the decision of the lower court, based on that rule of common law, was reversed, and it was held that—

"Each owner of soil lying in a belt which becomes saturated with percolating water is entitled to a reasonable use thereof on his own land, notwithstanding such reasonable use may interfere with water percolation in his neighbor's soil; but he has no right to injure his neighbors by an unreasonable diversion of the water percolating in the belt for the purpose of sale or carriage to distant lands.

"The owners of artesian wells sunk in the artesian belt of percolating water, the waters of which are necessary for domestic use and irrigation of their lands, on which are growing trees, * * * etc., are entitled to an injunction to restrain the diversion of the water

percolating in the artesian belt, by an owner of land situated in the belt, for the purpose of conveying the same to distant lands for sale, to the irreparable injury of the plaintiffs." (Katz *v.* Walkinshaw, 141 Cal., p. 116.)

The rule thus established for California is of far-reaching importance, and will probably form a precedent in the other States of the West where subterranean waters are necessarily relied on for irrigation purposes.

DAMMING OF UNDERGROUND WATERS.

Thus far we have been considering only such cases as involved the abstraction of underground waters. It is possible, however, to work damage to a neighbor by so obstructing the natural flow of underground water as to cause it to set back upon a neighbor's land and so flood it. Following the principle that a man may use that which belongs absolutely to him in any manner he may choose, it has been held that a landowner who obstructs underground waters within his own territory is not liable for any damage which may result to his neighbor. So in Vermont, where the owner of a mill pond raised the height of the water on his own land, thereby causing subterranean waters to set back and flood a neighbor's land, it was held that the owner of the pond was not liable for the damage caused. (Harwood *v.* Benton, 32 Vt., p. 724.)

On the other hand, in a similar case in New Hampshire, an opposite decision was rendered. (Bassett v. Salisbury Mfg. Co., 43 N. H., p. 569.) Where a miner stops up the exit from his mine into a lower mine, thereby causing the water to rise in the upper mine until it flows over into a neighbor's mine, he is not liable for the resulting damage. In some cases, however, an injunction will be granted against the one about to cause such damage. (Gould, pp. 572–573 and references.) And if one owner removes barriers by trespass, as by extending his works into his neighbor's mine, he is required to protect that mine against inundation, unless he has already been proceeded against for the trespass, and recovery had against him for it. (Gould, pp. 570–571 and references.)

DISPOSAL OF INTERCEPTED UNDERGROUND WATERS.

While a landowner is entitled to withdraw from his soil all the water he desires, even to the point of abstracting all the water from his own and his neighbor's land, having once intercepted such water for his use, he is responsible for the disposal of the same without damage to his neighbor. Having once intercepted and appropriated such water, he can not permit it to flow into his neighbor's land and effect damage there, even if it would have proceeded there and effected the damage had he not intercepted it. So a mine owner,

while he has a right to permit the water naturally flowing in his own mine to pass off by gravitation into the mine of his neighbor, provided his operations are carried on properly, yet will have no right to let such water pass off into the neighbor's mine after he has once collected or detained it for his own use.

The application of this rule to one particular case is of interest as showing the exact distinction made by the law regarding this point. Certain mine owners sunk a shaft on their property which tapped underground waters that formerly found their way into older workings on the same property, and thence into a neighbor's mine. The owners of the first property then made a borehole in the bottom of the shaft for the express purpose of letting off the water into the older workings, whence it percolated into the neighbor's mine precisely as before. The court decided that the owners of the shaft had appropriated the water, and were therefore responsible for any further damage caused by its flowing into the neighbor's mine. This seemed to be in accordance with the principle outlined above. But the case was appealed, and the former decision was reversed on the ground that the water in the shaft had not been appropriated at all, but merely altered in its course without even adding to the amount flowing into the neighbor's mine, or changing the time of its getting there. (West Cumberland Iron Co. *v.* Kenyon, 6 Ch. D., p. 773; 11 Ch. D., p. 782.) In New Hampshire it has been held that a landowner's right to alter the course of such waters is restricted to what is necessary in the reasonable use of his own property. (Gould, p. 558 and references.) In case underground water reaches the surface through an artesian well, the owner of the well may be prevented from allowing the water to flow into the streets of a city. (Skaggs *v.* Martinsville, 140 Ind., p. 476.) But in a case where water from an artesian well was allowed to flow into a natural watercourse which was "the only practicable outlet for the flow from such well," the owner of the well was held not liable to injunction. (Barnard *v.* Shirley, 135 Ind., p. 547.)

ARTIFICIAL PRODUCTION OF PERCOLATION.

While it has been held legal for a man to abstract percolating waters which are on their way to a stream or spring, or to a neighbor's well, and while he may even cause the water already in his neighbor's well to percolate out of it toward and into his own well (see preceding paragraphs), it has been held unlawful for him to construct a well or other structure near a running stream, and thus cause currents of percolating waters to develop, which would abstract water from such stream. There is thus a distinct difference between the right to take underground water before it reaches surface streams,

springs, etc., and the right to abstract water which is already a part of those surface accumulations. And since it is a principle of law that a man has no right to do indirectly that which he is not allowed to do directly, he can not take water from his neighbor's spring or stream by placing a drain or well only a few feet away, and thus letting such water run into his drain or well, when he is not allowed to take that water off directly by means of a pipe or ditch. As has been stated by one authority, "If you can not get at the underground water without touching the water in a defined surface channel I think you can not get at it at all." (Lord Hatherly, L. C., in Grand Junction Canal Co. *v.* Shugar, L. R., 6 Ch., p. 488.) Thus in a case where one proprietor constructed a drain close to a surface stream, with the result that the drain drew off the water flowing in the stream, to the damage of a neighbor, an injunction was granted preventing the unlawful act. (Grand Junction Canal Co. *v.* Shugar, L. R., 6 Ch., p. 483.) So also in a Massachusetts case it was held that "a person can not draw water from a pond by percolation if he has no right to draw it therefrom directly." (Proprietors of Mills *v.* Braintree Water Supply Co., 149 Mass., p. 478.)

It will readily appear that some difficulty must frequently be found in determining whether or not the artificial structure actually results in the abstraction of water from a surface stream or other body of surface water. The mere proximity of a well to a stream, for instance, does not prove abstraction. Neither does the diminution of water in the stream, since the well may only secure percolating water which has not yet reached the stream. The farther the well is removed from the stream, the more difficult will it be to satisfactorily establish the fact of abstraction. The party that complains of abstraction has all the burden of this proof, and must fully establish the fact that the well or other structure does draw off water from the surface accumulation before the one causing the damage will be held responsible.

ARTIFICIALLY INCREASED PERCOLATION.

It often happens that the natural percolation of a portion of soil is locally increased by various artificial means, as by the pressure of large amounts of water collected in a reservoir, or the sinking and cracking of the surface above mine excavations, thereby admitting water which would otherwise flow off into surface streams. The tendency of the law is to regard this as a "nonnatural" use of the land, and to hold the land owner responsible for any damage he may cause. In Pennsylvania a mine owner is required to leave proper support for the surface of the ground above his mine, and if he fails to do this, and the surface of the ground sinks and cracks as a result,

letting surface waters flow into his mine and from there percolate into the mine of his neighbor, he is liable for any resulting damage. (Gould, p. 572, footnote.) But in another case where a mine owner so disturbed the soil above his workings as to produce fissures in it which let the natural rainfall on the surface pass into his mine and thence by gravitation into his neighbor's mine, the mine owner causing the damage was not held liable. (Wilson *v.* Waddell, 2 App. Cas., p. 95.)

In a certain case a reservoir was constructed for accumulating water, and the contractor failed to provide sufficient support to resist the pressure of the water in certain old shafts which communicated with old coal workings, the existence of which was then unknown to the owners of the reservoir or any of those in their employ. The result was that the weight of the water caused it to break through the shafts, whence it passed through the old coal workings into a neighbor's mine. No negligence on the part of the owners of the reservoir appearing, it was held that they were not liable for the injury. This decision, however, was reversed in the higher courts, and the owners were held liable for the damage caused, since "foreign water had been sent down upon the plaintiffs, and the defendant's lack of knowledge thus became immaterial." It was held that "the person who, for his own purposes, brings on his land and collects and keeps there anything likely to do mischief if it escapes, must keep it in at his peril, and if he does not do so, is prima facie answerable for all damage which is the natural consequence of its escape." (Rylands *v.* Fletcher, L. R., 3 H. L., pp. 330, 339, etc.) This principle has since been applied to "injuries resulting to adjoining land from the percolation of the waters of an artificial reservoir or canal through the soil; to water allowed to collect in a cellar and to percolate into the plaintiff's cellar or well adjoining; to dampness caused in the plaintiff's house by an artificial deposit near by of spongy soil and clay." (Gould, pp. 574, 575.) In a number of the States the above principle is modified to the extent that in order to hold the party liable for damage caused it must be shown that he was guilty of negligence. The principle does not apply in cases where the artificial accumulation of water was for the mutual benefit of both parties to the suit; nor where the accumulation was made for public purposes under express authority of a statute, no negligence being proven; nor where the accumulation was not made by the landowner intentionally and for his own benefit, as in the case where a house was destroyed by fire, and water collected in the uncovered cellar, thence flowing against the walls of an adjoining house built after the first house was destroyed. (Gould, pp. 575–576, and references.) In such cases no damages are recoverable.

POLLUTION OF UNDERGROUND WATERS.

The fact that a man has absolute right to the underground waters within his territory, and may abstract those waters entirely, even to the point of draining his neighbor's land, does not give him the right to poison or foul those waters and allow them to pass into his neighbor's land in such condition. Such an act is illegal, and he who causes the damage is generally held liable even if he is not guilty of negligence, "he whose filth it is being required to keep it on his premises at his peril." This is the principle laid down in the leading case of Rylands *v.* Fletcher, cited above. A marked distinction is drawn between the right to use all the underground water and so prevent its use by a neighbor, and the right to poison or contaminate that water so that when it does reach that neighbor it is unfit for use.

In a case where casks of oil stored in a warehouse leaked so that the oil entered the ground and indirectly polluted a neighboring spring, the owners of the warehouse were held liable for the damage although they were ignorant of the fact that the oil was affecting the spring. (Kinnaird *v.* Standard Oil Co., 89 Ky., p. 468.) So in a case where a man permitted sewage to flow into his neighbor's well, he was held liable for the damage, the opinion being given that "The right to foul water is not the same as the right to get it; and in my opinion does not depend on the same principles. * * * the law of nuisance is not based exclusively on rights of property." (Ballard *v.* Tomlinson, 29 Ch. Div., pp. 115, 126.)

In setting forth this same principle it has been said: "It does not follow that because I have a right to use a thing on my own land I may lawfully send it into my neighbor's premises in a condition to work an injury to him. * * * The American cases, therefore, while recognizing to its fullest extent the right of every landowner to use, detain, and even totally abstract all the underground percolating water, * * * yet quite agree with the decision * * * that he is liable for corrupting it and thus causing an injury to the well of an adjoining owner. * * * The true cause of action * * * is not exactly that the defendant contaminated underground percolating water, but that he allowed his impure sewage to escape from his premises to the plaintiff's, and the circumstances that it reached there by underground percolation instead of by a surface stream is quite immaterial." (E. H. Bennett, 24 Am. Law Reg., pp. 638, 640.)

In cases where substances from the works of a gas company have percolated into the soil, resulting in injury to a neighbor's well, the company has been held liable for the damage. In a case where it was shown that other things besides the escape of gas into the water of a well contributed to make it unfit for use, it was held that the

gas company was liable for damage to the water, although the fact that there were other sources of corruption might be shown in mitigation of the amount of damage recoverable. (Sherman *v.* Fall River Iron Works Co., 5 Allen (Mass.), p. 213.)

So when filthy water from a vault percolates through the ground and injures the cellar and well of a neighboring proprietor, the party who maintains the vault is liable for the damage. (Ball *v.* Nye, 99 Mass., p. 582.) Likewise where poorly constructed sewers permit filth to percolate from them into the cellars of adjoining premises the one who maintains such sewer is liable for resulting damages, "even if he is the owner of the premises into which the filth percolated, and the parties complaining were his own tenants." (Alston *v.* Grant, 3 El. and Bl., p. 128.)

In a case where a person polluted his own well with sewage, and the contaminated water percolated into a neighbor's well, it was claimed that the party causing the damage was not liable, since the neighbor whose well was injured secured the water from that well by artificial means—i. e., by pumping. The court held the party liable for the damage he caused, however; Brett, M. R., stating that "The plaintiff, if he has a right to use anything in nature, has a right to exercise that use by all the skill and invention of which a man is capable, and it seems to me that as long as the plaintiff uses only lawful means as against his neighbor, however ingenious or however artificial those means may be, his right to appropriate the common source is not diminished because he used the most artificial or most ingenious methods." (Ballard *v.* Tomlinson, 29 Ch. Div., p. 122.)

In cases where it can be shown that the acts of another will result in a pollution of underground waters, the courts will grant injunctions to prevent such injury. Thus a perpetual injunction was granted to restrain a party from allowing unclean refuse matter to pass from his manufactories into an old pit on his own land, since it percolated thence into a neighbor's colliery. (Turner *v.* Mirfield, 34 Beav., p. 390.) In another case a party was prevented by an injunction from using a cesspool through which water percolated into a neighboring well. (Womersley *v.* Church, 17 L. T. N. S., p. 190.) So also an injunction will be issued to prevent the establishment of a burial ground, when it can be shown that the burial of the dead there will endanger life or health by corrupting the surrounding atmosphere or the water of springs or wells. (Clark *v.* Lawrence, 6 Jones's Eq. (N. C.), p. 83; 78 Am. Dec., p. 241.) There must be clear proof of probable injury, however. It has elsewhere been held that cities have absolute authority to establish cemeteries, and discretion to judge of their necessity. (Greencastle *v.* Hazelett, 23 Ind., p. 186.) In a case where a party was about to erect a privy on his own lot, about

8 feet from his neighbor's house and cellar, and less than 20 feet from his well, the completion of the privy was prevented by injunction. The court, quoting another authority, said: "Privies are regarded as prima facie nuisances, and although necessary and indispensable in connection with the use of property for the ordinary purposes of habitation, yet if they are built or allowed to remain in such a condition as to annoy others in the proper enjoyment of their property by reason either of the noisome smells that arise therefrom or by the escape of filthy matter therefrom upon the premises of another, or so as to corrupt the water of a well or spring, they are nuisances in fact." (Wahle *v.* Reinbach, 76 Ill., pp. 322, 326.)

There are a few exceptions to the above rules, however, it being held in several cases that the party causing the pollution of underground water is not liable for damage caused to a neighboring proprietor unless guilty of negligence or malice. In one such case the court observes, "If withdrawing the water from one's well by an excavation on adjoining lands will give no right of action, it is difficult to understand how corrupting its waters by a proper use of the adjoining premises can be actionable, when there is no actual intent to injure and no negligence. The one act destroys the well, and the other does no more; the injury is the same in kind and degree in the two cases." (Cooley, J., in Upjohn *v.* Richland Township, 46 Mich., pp. 549, 550.)

So in a case where the operator of gas works placed obnoxious substances near a neighboring property, and portions of these substances were washed along the surface into the neighbor's well, and other portions penetrated into the ground, thus polluting the subterranean currents which supplied the well, the court held that while the operator was liable for the surface pollutions, he was not liable for any damage to the well resulting from the pollution of underground currents of water unless he acted maliciously. (Brown *v.* Illius, 27 Conn., p. 84.) In another case the party polluting underground streams whose channels and courses were unknown and undefined, was held not to be responsible for the damage caused. (Dillon *v.* Acme Oil Co., 49 Hun. (N. Y.), p. 565.) In this case a distinction was made between contaminating a subterranean stream whose channel and course were undefined and unknown, and contamination by percolation or soaking. This, also, seems contrary to the general rule of law, which makes no distinction between ordinary percolating waters, and such underground streams as have channels and courses which are indefinite and unknown.

In a case where a party sunk an artesian well upon his own land and used the water to bathe the patients in a sanitarium or hospital erected by him on his premises, and then allowed the polluted water to flow into a natural watercourse, which was the only practicable out-

let for the flow from the well, the party was held not to be liable for the resulting damages, providing he was free from negligence and malice and used due care to avoid injury to his neighbors. (Barnard *v.* Shirley, 135 Ind., p. 547.) This decision seems contrary to the general ruling of the courts in a twofold way, since it is generally held that one who intercepts and uses underground waters is responsible for their future course (pp. 21–22), and the pollution of waters is usually illegal whether or not there be malice or negligence.

The principle upon which the decisions in these exceptional cases is based seems to be that a man's obligations to preserve the purity of underground waters is limited to the reasonable and proper use of such waters, without negligence or malice on his part. According to this principle, any damage to a neighbor which is necessary and unavoidable, or not sufficiently obvious to have been foreseen, resulting from a landowner's proper and reasonable use of his land, is not held to be a legal injury.

Having now outlined the general relations of the law to the abstraction, diversion, and interruption of underground waters, and to the pollution of the same, it remains to be pointed out in what ways the general rules are modified, if at all, (1) by the motive with which the acts complained of were done; (2) by definite agreements between the parties respecting the use of the underground waters; (3) by prescription, or the long-continued use and enjoyment of such waters.

EFFECT OF MOTIVE.

Although an act may in itself be perfectly legal—as, for instance, the abstraction of underground waters from the soil, even to the point of rendering dry a neighbor's well, is generally held to be—it might be considered that a person who exercised such right with the malicious and evil intention of hurting his neighbor would be guilty of a legal injury. This question as to the effect of motive has given rise to a number of conflicting opinions.

So far as the pollution of underground waters is concerned there is little disagreement among authorities, it being generally held that, however innocently the contamination is effected, the party causing the damage is none the less liable for it. As we have seen, however, there are cases in which the party was not held responsible, provided he was guilty of no negligence and entertained no malicious motives.

In cases involving the abstraction or diversion of underground waters with malicious intent to injure a neighbor opinions have been more conflicting. The weight of authority, especially in more recent cases, is to the effect that the motive is immaterial, according to the principal that the law must deal with outward acts and not with inward motives. "When the use which a landowner makes of his property is lawful in itself, the law will not take cognizance of the motive

which prompts the use, even where it results in damage to another." (Enc., 434.) So it has been held that while "malicious motives make a bad act worse, * * * they can not make that a wrong which in its own essence is lawful." (Black, J., in Jenkins *v.* Fowler, 24 Penn. St., p. 310.) According to another authority, "Bad motives in doing an act which violates no legal right of another can not make the act a ground of action." (T. R. Strong, J., in Pickard *v.* Collins, 23 Barb. (N. Y.), p. 459.) In another case the court observes, "As an act unlawful in itself resulting in injury to another, whatever may have been the motive with which it was done, is none the less the subject of legal redress, so the act done, to wit, the using of one's own property, being lawful in itself, the motive with which it was done—whatever it may be as a matter of conscience—is in law a matter of indifference." (Brinkerhoff, J., in Frazier *v.* Brown, 12 Ohio St., p. 311-312.) So, also, in another case, "We have not given any attention to the alleged motives of the defendants. Their motives are immaterial. The question is only as to their rights." (Rodman, J., in Porter *v.* Durham, 74 N. C., p. 780.)

In accordance with the above opinions was the decision rendered in the following case: A landowner possessed a mineral spring surrounded by an artificial embankment. His neighbor dug a well on his own land, striking a vein of mineral water, evidently intimately connected with the adjacent mineral spring, and the water from this vein rose high enough to be conducted by pipes to the neighbor's bath house. Then the owner of the spring, for no purpose beneficial to himself and simply to divert the water from his neighbor's well, lowered the embankments about the spring, thereby cutting off the supply of water from the neighbor's well. It was held that the owner of the spring was not liable, the question of motive not affecting his legal right. (Phelps *v.* Nowlen, 72 N. Y., p. 39.) As stated by another authority, "It is generally held that no action will lie against one for acts done upon his own land, in the exercise of his rights of ownership, whatever the motive, if they merely deprive another of advantages or cause a loss to him, without violating any legal right; that is, the motive in such cases is immaterial." (Wells, J., in Walker *v.* Cronin, 107 Mass., p. 564.)

In striking contrast to the above are cases in which the authorities consider the motive as an important factor in the case. Thus it has been held that "neither the civil law nor the common law permits a man to be deprived of a well or spring or stream of water for the mere gratification of malice." (Lewis, C. J., in Wheatley *v.* Baugh, 25 Penn. St., p. 533.) In another case the opinion was given: "Ordinarily a landowner may dig a well upon his own land, even though, by percolation, it draws the water from his neighbor's land, or even his well; but it would present a very different question if the well was

dug by him with the express purpose of transferring the water in his neighbor's spring or well to his own, and knowing that this would be the result." (Bellows, C. J., in Swett *v.* Cutts, 50 N. H., pp. 446–447.)

According to another authority, "While a man has no right to protection against competition, he has a right to be free from malicious and wanton interference, disturbance, and annoyance." (Barrows, J., in Chesley *v.* King, 74 Me., p. 175.)

EFFECT OF GRANT OR AGREEMENT.

It seems to be well established in the courts that where one party grants certain water rights to another or makes an agreement with him regarding rights to underground waters, the parties shall be bound by the terms of the grant or agreement, and not by the rules of law applicable to underground waters in general. Thus, while in general a man may lawfully dig a well on his own land, even though he thereby drain off the water from his neighbor's well or spring, he can not do so if his act violates a grant or an agreement with that neighbor. But in cases where the act complained of does not violate any express provision of the grant or agreement, the usual rules of law are considered to apply. The following cases serve to illustrate the several phases of the question.

A party granted the surface of his land to another, but reserved the mines below. In the operation of his mines the water was all drained from the surface, thus damaging the one to whom he had made the grant. He was not held to be responsible for the damage, since he had made no express agreement regarding such waters. (Ballacorkish Mining Co. *v.* Harrison, L. R., 5 P. C., p. 49.) And where a man sells a well to another, and then by digging another well or in some other manner prevents percolating water from reaching the well he has sold, he is not liable for the damage if the sale of the well does not carry with it a guarantee of a regular supply of water. (Gould, p. 562, and references.) So, also, with a spring. "A grant of a 'certain spring or fountain of water' does not deprive the owner of the land of the right of properly draining his land to make it productive, even though in some unknown mode the drainage of the land may affect his supply of water." (Enc., p. 431, footnote and references.) In a case where one party purchased land from another with the agreement that the other should have a right to conduct water from a spring on the land thus sold to his adjoining property, and then the purchaser dug a well on the land which he had bought, destroying the spring from which he had agreed to let the other conduct water, it was held that the purchaser was not responsible for the damage, since the agreement did not entitle the other to an uninterrupted flow of the water. (Enc., p. 431, footnote and references.) Where one party granted another the right to draw water from a certain

well by a pipe laid in the ground, he was not prevented from digging another well or reservoir on his own land, thereby diverting the water which formerly percolated into the well. (Davis *v.* Spaulding, 157 Mass., p. 431.) In cases where the effect of the grant is to make the parties to it practically adjacent owners, the usual rules of law apply.

But where the terms of the grant or agreement plainly secure a regular supply of water to the one to whom such grant is made, one who interferes with underground waters so as to diminish or interrupt the supply will be held liable. Thus, in a case where a proprietor granted to a manufactory situated on his land the use of water conducted to the factory from springs on his land, and "covenanted to warrant and defend the granted premises against himself and all other persons," and then withdrew the supply from such springs, he was held liable for the damage. (Johnstown Cheese Mfg. Co. *v.* Veghte, 69 N. Y., p. 16.)

In another case a man owned two adjoining farms, on one of which was a spring from which water was conducted in pipes to the barnyard of the other. He sold this latter farm with appurtenances, but without special mention of spring and pipes. Then he dug a well near the spring, thereby lowering the water in the latter till it failed to flow through the pipes. It was held that he could be restrained from using the well causing the injury on the ground that the uninterrupted flow of water was essential to the full enjoyment of the estate conveyed. (Paine *v.* Chandler, 134 N. Y., p. 385.) This appears to be a departure from the general rule, unless "appurtenances" is interpreted as including the waters percolating into the spring on adjacent land, for in cases where the opposite decision was rendered, as noted above, the uninterrupted flow of the water was even more certainly essential to the full enjoyment of the well or spring conveyed.

When the privilege of taking water from springs of a certain locality is granted the waters can only be taken where they naturally come to the surface, not from wells or other orifices where the water does not come to the surface. (Enc., p. 431, footnote and references.)

A grant of a well or spring carries with it the right to the land immediately occupied by such well or spring. So the well is held to include "the orifice reaching down to the water, the whole opening in the earth before it is stoned, the stone laid in the wall, and the water therein." Where a spring was set apart and separated from other lands so as to extend three rods each way from the central portion covered by water, the word "spring" in a deed was held to include this land. (Gould, p. 563 and references.)

EFFECT OF PRESCRIPTION.

In law the use and enjoyment of things "from time immemorial" is held to give a legal right to certain of the things thus used and

enjoyed. This is known as the right arising from "prescription," but this right can not exist with regard to underground waters, it being held that the owner of land can not acquire by prescription the right to receive percolations through the land of another. This is clearly set forth in the following opinion: "The doctrine of prescription, presumption of grant from lapse of time, can have no proper application to the question. (1) Because the party against whom the doctrine will have to be applied could not be reasonably required to enter his caveat against the appropriation of a thing so hidden and obscure as is percolating underground water; and (2) because the appropriation of such water by an adjoining proprietor is not an infringement of his rights, so as to become the subject of legal redress, until such time as he himself has occasion to appropriate them." (Brinkerhoff, J., in Frazier *v.* Brown, 12 Ohio St., p. 311.)

SUMMARY AND CONCLUSIONS.

In summing up the generalities of the relation of the law to underground waters it is to be noted that wherever a subterranean stream can be shown to have a defined and known channel it is considered subject to the same rules of law that apply to surface streams; but where subterranean streams have channels which are indefinite and unknown, or where subterranean waters percolate through the ground independent of channels, different rules of law are applicable. Regarding the laws controlling the use of this second class of underground waters a number of points have been noted.

It has been seen that, according to a large number of decisions, a man is entitled to practically absolute control of such underground waters in his own land, but that some authorities limit him to a reasonable and proper use of such waters. The destruction of a well or spring as a result of an adjacent landowner's excavating a well, spring, cellar, mine, or ditch upon his own land is generally held to be a damage for which there is no remedy at law. But some authorities hold that in order to escape liability for such damage the party causing it must have made such use of his land as is reasonable and proper. Where the damage is caused by a corporation, as by a railroad company excavating on its right of way, damages are in general recoverable, although it has been held in some cases that such a company is no more liable for damage caused by excavations on its right of way than is a private citizen for damage resulting from excavating on his own land. It is to be noted that in the irrigation States of the West the cases are likely to be decided on different principles from those governing decisions in the East. To this effect is the California decision that "the common law rule that percolating water belongs unqualifiedly to the owner of the soil, and that he has the

absolute right to extract and sell it, is not applicable to the conditions existing in a large part of this State, where artificial irrigation is essential to agriculture, and artesian wells in percolating belts are necessarily used for that purpose." (Katz *v.* Walkinshaw, 141 Cal., p. 116.)

Where surface streams are injured by a loss in volume due to the fact that a well or other excavation on a neighbor's land intercepts the percolating waters supplying the stream, it is generally held that there is no redress for the damage, but some authorities hold that the one causing the damage is responsible for it. If a man makes a well or other excavation near a stream or other body of surface water, and thereby extracts water which has already become part of a surface accumulation, he is responsible for the resulting damage.

Where land is injured by the withdrawal of the underground water through a neighbor's well or other excavation, so that the land fails to support crops, or sinks and cracks, it is usually maintained that there is no remedy at law, although there are exceptions to this ruling. Where the obstruction of underground waters made such waters set back and overflow a neighbor's land, it was held in one case that the party causing the damage was not liable, while the opposite decision was rendered in another and similar case.

One who intercepts underground waters and appropriates them for his own benefit is in general responsible for any damage they may cause thereafter, even if the damage is the same as the waters would naturally have caused if not intercepted. But an opposite decision has been rendered in at least one such case. One who merely alters the course of percolating waters and does not appropriate them for use is not generally responsible. In one State, however, it is held that the right to alter the course of underground waters is restricted to what is necessary in the reasonable use of property.

Any one who artificially increases the natural amount of percolation is, according to some authorities, responsible for the resulting damage, but others hold that unless the damage is the result of negligence or malice no legal redress can be obtained.

The pollution of underground waters is generally held to be illegal, whatever the circumstances attending such pollution. But a few authorities maintain that such pollution is not illegal unless there is evidence of negligence or malice.

In case any of the foregoing acts, which are legal in and of themselves, is done with the express purpose of injuring a neighbor, some authorities hold that the one committing such an act with malicious motive is responsible for the damage he causes. But others, and perhaps the majority, take the position that such an one is not liable, since the motive is immaterial.

Where any of the foregoing acts, in themselves legal, violates the express terms of a grant or an agreement, the act becomes illegal.

No special right to underground waters can be acquired by long continued use and enjoyment of the same.

Such a review affords ground for careful reflection concerning the laws of underground waters. One is impressed with the great lack of agreement among authorities respecting many of the points at issue. The law of waters in general is an intricate problem, and it is not to be expected that the unsatisfactory feature referred to will ever be wholly eradicated. It is probable, however, that a better appreciation of some of the facts established within recent years by various investigations into subterranean conditions will result in more harmonious opinions, and make possible a more just administration of the laws in question.

The great lack of agreement among authorities on questions pertaining to underground waters is due in part to the nature of the problems involved. There is so much that is uncertain and indefinite in the behavior of waters hidden beneath the surface that more or less uncertainty must unavoidably attach to the laws respecting them. Perhaps the only practicable remedy is to be found in the removal, so far as it is possible, of the uncertainty and indefiniteness by an extension of our knowledge of subterranean conditions. Marked advances have already been made in this direction, and many questions may be settled to-day far more equitably than was possible a few years ago.

It is believed that a second and very important reason for the unsatisfactory condition of the law relating to underground waters is to be found in the fact that the state of our knowledge regarding such waters is now in advance of the general ruling of the courts on some of the questions involved. The earlier legal decisions and authoritative opinions were made at a time when very little was known regarding that which was beneath the surface. The fundamental conception upon which many of the opinions rest is that we are ignorant of the conditions controlling waters hidden from our view. Since that time the progress of geological science has wrested from the unknown many things regarding underground waters and firmly established them in the realms of known fact. These things should serve to make possible a more equitable settlement of controversies involving rights to underground waters; and where a decision is controlled by opinions rendered in former cases, and not made with due regard to the present knowledge respecting subterranean conditions, it does not seem that a just settlement of the controversy can be reached.

That the earlier decisions and opinions serve as a guide for later

decisions is a fact known to those who are familiar with our legal procedure, and is evident on reading the decisions handed down in the various cases. Even where a certain judge was convinced from the evidence that the older decisions were manifestly wrong when applied to the case under consideration, the additional facts available in that case having thrown new light on the problem involved, nevertheless he felt compelled to decide in accordance with established precedents and against what he believed to be the right. (Collins *v.* Chartiers V. Gas Co., 131 Penn. St., pp. 159–160.) The higher courts in this instance reversed his decision. The case serves to call attention to the importance of emphasizing the influence which the ever-increasing knowledge concerning underground waters may and should have in governing legal decisions. The need of acquainting the public with such facts as are ascertained by the drilling of wells, the excavating of mines, and the investigations of public or private surveys is evident.

This point has been well appreciated by Mr. Justice Mitchell, who observed, "Geology is a progressive, and now, in many respects, a practical science, and, as truly remarked by the learned judge below, in his opinion on the motion for a new trial, 'Since the decision in Acton *v.* Blundell and Wheatley *v.* Baugh, probably more deep wells have been drilled in western Pennsylvania than had previously been dug in the entire earth in all time. And that which was then held to be necessarily unknown and merely speculative, as to the flow of water underground, has been, by experience in such cases as this, reduced almost to a certainty.' If this is the state of knowledge at the present day; if the existence of a stratum of clear water, and its flow into wells and springs of the vicinity, and the existence of a separate and deeper stratum of salt water, which is likely to rise and mingle with the fresh, when penetrated in boring for oil or gas, are known, and the means of preventing the mixing are available at reasonable expense, then, clearly, it would be a violation of the living spirit of the law not to recognize the change, and apply the settled and immutable principles of right to the altered conditions of fact." (Collins *v.* Chartiers V. Gas Co., 131 Penn. St., pp. 159–160.)

In many cases the original lack of knowledge, which was the efficient reason for the ruling of the law has already disappeared. It is sufficient for the present purpose to call attention to a few concrete instances. Thus, as stated by one authority, it has been held "that injury to springs, wells, etc., supplied by mere percolation, was not actionable, and the reason has always been the same, that the damage could not be foreseen or avoided." We are now in possession of definite knowledge concerning the amount, rate, and direction of flow of underground water in certain cases, as well as concerning the thickness of the water-bearing stratum, its depth below the surface,

and other valuable facts. In such cases it may often be possible to foretell with certainty that a given well or excavation will affect the supply of a neighboring well or spring. The damage may, therefore, be certainly foreseen. It may also be possible to show how a different position of the well would decrease the interference, or prevent it entirely, and thus avoid the damage to a greater or less extent. The damage may, therefore, be avoided in cases. The statutes of South Dakota and one or two other States recognize this possibility to foresee and prevent well interference, and make due provision for it.

So also it is now possible, in many cases, to predict with certainty what course would be taken by polluting substances carried by underground percolations, and so foretell which wells or springs would probably suffer and which would not. By noting the inclination and character of the rocks it has been possible to show that the polluted waters from a cesspool on one side of a hill would without doubt be carried down the slope of the beds, through the hill, to a spring on the opposite side. The course of such waters may in cases be demonstrated experimentally.

In one of the leading cases on this subject it was argued that "there is an absolute impossibility for anyone to know what are the underground currents, where they begin, what they produce, and in what direction they run, and consequently an absolute impossibility of knowing what are the rights in relation to them." To-day we do know, in numerous cases, what the underground currents are, where they begin, in what direction they run, and even at what rate they progress, of what volume they are, and what in general are their vertical and lateral extents. So we might now say that there is a possibility of knowing and defining what are the rights in relation to them.

According to some authorities percolating waters are to be compared with the rocks and minerals contained in the ground, and absolute ownership accorded the landowner on the same principle in both cases. Such is the idea expressed by Joseph K. Angell in his treatise on The Law of Water Courses (5th edition, pp. 110–111), in the following words: "* * * in contemplation of law, land always extends downward as well as upward; so that whatever is in a direct line between the surface of any land and the center of the earth belongs to the owner of the surface. It would consequently seem to follow that whether what is subterranean be solid rocks, mines, or porous soil, or salt springs, or part land and part water, the person who owns the surface may dig therein and apply all that is there found to his own purposes ad libitum."

It seems to me that this principle is essentially erroneous. We now know that percolating waters may and usually do possess a

definite course, that in certain cases they enter the ground at given localities which may often be determined with accuracy, that they often have a certain flow with a fairly definite velocity year in and year out, and that they exist at certain depths below the surface. It is evident, then, that such waters are not to be compared with rocks and minerals which are, as such, stationary in the soil where they occur until removed by some external power; but that they are better to be compared with those waters upon the surface which pass into the land from one direction and out of it in another, and which are not regarded as the absolute property of the landowner. Furthermore, the removal of the rocks and soil from the land of one owner does not take away the rocks and soil belonging to his neighbor: while the removal of percolating water from the land of one owner does result in taking away the percolating water belonging to that neighbor. In other words, there certainly is a common interest in the water which does not exist in the case of the rocks and soil. As has been well said by Justice Temple, "It is obvious at once that the analogy between the right to remove sand and gravel from land for sale and to remove and sell percolating water is not perfect. If we suppose a saturated plain, one may remove and sell the sand and gravel from his land without affecting or diminishing the sand and gravel from the lands of his neighbors. * * * But when he drains out and sells the water on his land he draws to his land, and also sells, water which is the property of his neighbor. * * * In short, the members of the community, in the case supposed, have a common interest in the water. It is necessary for all, and it is an anomaly in the law if one person can, for his individual profit, destroy the community and render the neighborhood uninhabitable." (Katz *v.* Walkinshaw, 141 Cal., p. 140.)

It is believed therefore that absolute ownership of percolating waters can not be properly granted to any landowner on the basis of the principles here considered; but must be granted, if at all, on the ground that our ignorance of subterranean conditions, or considerations of public policy, make such a ruling necessary. With the disappearence of the ignorance in question one of the reasons for such a law disappears, and it remains to be seen what provisions of the law, in the light of new facts, are justified by considerations of public policy.

As was pointed out at the beginning of the discussion of underground waters of the second class, some authorities justify the refusal of the common law to recognize correlative rights in respect to such waters on the ground that "the existence, origin, movement, and course of such waters, and the causes which govern and direct their movements, are so secret, occult, and concealed that an attempt to

administer any set of legal rules in respect to them would be involved in hopeless uncertainty, and would be therefore practically impossible." At the present time our knowledge of the workings of underground waters, of their origin, movement, and courses, and of the causes which govern their actions, leaves much less in the realm of the "secret, occult, and concealed." It is possible to define certain rights in these waters, and to protect those rights as well as those in surface waters. As has been recently held by a California court: "The difficulties which the courts will meet in securing persons necessarily using percolating water for irrigation by means of artesian wells, from the infliction of great wrong and injustice by its diversion, if property rights therein are recognized, can not justify the court in abandoning the task as impossible. The courts can protect this particular species of property in water as effectually as water rights of any other description." (Katz *v.* Walkinshaw, 141 Cal., p. 116.)

There yet remains much that is uncertain regarding subterranean conditions; but as, in the past, geology has added much to our store of knowledge concerning those conditions, so in the future we may confidently expect a continued increase in the known facts. And with this increase in knowledge we should look toward an increasingly satisfactory adjustment of those controversies which arise concerning subterranean waters. There probably must always be cases in which the subterranean conditions are indefinite or unknown, but the number of such cases will decrease; while it will be possible to adjust a constantly increasing proportion of the cases more equitably than was possible in the days when practically nothing was known about that which lies hidden beneath the surface of the ground.

The lack of agreement among legal authorities on many of the questions at issue is rather more fortunate than unfortunate in one respect at least, since it bears witness to the uncertain position of the law on the points involved and opens the way more readily for new knowledge bearing on the problems. Where the court is not bound by a long and unbroken line of legal authority, its decision is more apt to be in accordance with the general principles of right as applied to the present state of knowledge regarding the problem under consideration. More importance will attach to a complete and searching investigation into all the facts of the case in hand, since less will depend upon decisions rendered in similar cases years ago.

CHAPTER II.

LEGISLATIVE ACTS AFFECTING UNDERGROUND WATERS.

INTRODUCTION.

It has been thought advisable to present a brief review of the more important legislation enacted by the different States and Territories on the subject of underground waters. No attempt has been made to gather every reference in State laws to the subject, but it is believed the following summary will give a fairly accurate idea of the extent of such legislation and will furnish the reader with the most important provisions relating directly to the control of waters flowing beneath the surface of the ground.

It will readily appear that most of the legislation on this subject has arisen in connection with the sinking of artesian wells for the purpose of securing underground water for domestic and mechanical purposes, and more especially for irrigation. In some of the Western States, where irrigation is largely dependent on artesian wells, this class of underground waters occupies a prominent place in the State laws.

Much of the legislation on this subject refers only indirectly to the underground water itself, being concerned with the duties of officials in regard to the sinking and controlling of wells, the appropriation of money, and the levying of taxes to provide for the cost of such wells, the rights and duties of those benefited by the water thus secured, and other topics of this general class. Material of this character has been omitted, brief references sometimes being given to the reports where it may be found.

Most of the States having special laws relating to underground waters are given below in alphabetical order, with such reference to their laws as seemed desirable for the purpose of this report.

CALIFORNIA.

The laws of California provide for the regulation of the use of artesian wells and prohibit the waste of subterranean waters. In an act (L., 1877–78, p. 195), approved in 1878, it is provided (sec. 1) that:

"Any artesian well which is not capped or furnished with such mechanical appliances as will readily and effectively arrest and prevent the flow of water from such well is hereby declared to be a public nuisance. The owner, tenant, or occupant of the land upon

which such well is situated who causes, permits, or suffers such public nuisance, or suffers or permits it to remain or continue, is guilty of a misdemeanor."

Also (sec. 2) that:

"Any person owning, possessing, or occupying any land upon which is situated an artesian well, who causes, suffers, or permits the water to unnecessarily flow from such well or to go to waste, is guilty of a misdemeanor."

For the purposes of this act an artesian well is defined (sec. 3) as "any artificial well the waters of which will flow continuously over the surface of the ground adjacent to such well at any season of the year;" and waste is defined (sec. 4) as follows: "The causing, suffering, or permitting the waters flowing from such well to run into any river, creek, or other natural water course or channel, or into any bay, lake, or pond, or into any street, road, highway, or upon the land of any person other than that of the owner of such well, or upon the public lands of the United States or of the State of California, unless it be used thereon for the purposes and in the manner that it may be lawfully used upon the land of the owner of such well: *Provided*, That this section shall not be so construed as to prevent the use of such waters for the proper irrigation of trees standing along or upon the street, road, or highway, or for ornamental ponds, or for the propagation of fish."

A fine of not less than $10 or more than $50, together with the cost of prosecution, is assessed against those convicted of violating any of the provisions of this act, and the supervisors or roadmasters are empowered to enter upon the premises where wells complained of are situated, and to institute criminal action where violation of the provisions of this act is discovered.

COLORADO.

The laws of Colorado regulate the use of artesian wells and prohibit the waste of subterranean waters in much the same way as the laws of California above cited. Further provisions are made for the keeping of accurate records of the depth and thickness of the different strata penetrated, for determining the legal status of seepage or spring waters, and for the sinking of certain artesian wells.

An act (L., 1887, p. 52) approved in 1887 provides (secs. 1 and 2) that: "Any artesian well which is not tightly cased, capped, or furnished with such mechanical appliances as will readily and effectively prevent the flow of water from such well is hereby declared to be a public nuisance. The owner, tenant, or occupant of the land upon which such well is situated, who causes, permits, or suffers such public nuisance, or suffers or permits it to remain or continue, is guilty of a misdemeanor.

"Any person owning, possessing, or occupying any land upon which is situated an artesian well, who causes, suffers, or permits the water to unnecessarily flow from such well, or to go to waste, is guilty of a misdemeanor."

For the purposes of this act an artesian well is defined much the same as under the California law above cited, except that it is provided that nothing in the act shall apply to water flowing from mining shafts, and the definition is made to read, "the waters of which, if properly cased, will flow continuously," etc.

Waste is defined as in the California law, with a few minor modifications in the wording, and with the provision that the use of the water for agricultural purposes is allowed in addition to the other uses enumerated above.

A fine of not less than $50 nor more than $300, together with the cost of prosecution, is assessed against anyone violating any of the provisions of the act. The county commissioners, road overseers, city engineer, or city officers are empowered to investigate and prosecute alleged violations of the act.

It is further provided (sec. 7) that: "Any person boring or causing to be bored an artesian well, shall keep a complete and accurate record of the depth and thickness of the different strata penetrated, and when such well is completed, shall file such record in the office of the county clerk and recorder of the county within which such well is situated, and immediately transmit a copy of such record to the office of the State engineer. Any person violating the provisions of this section shall be deemed guilty of a misdemeanor and shall, upon conviction, be fined not less than ten nor more than fifty dollars."

By an act (L., 1889, p. 215), approved in 1889, the rights relating to the use of seepage and spring waters are defined as follows: "All ditches now constructed or hereafter to be constructed for the purpose of utilizing the waste, seepage, or spring waters of the State shall be governed by the same laws relating to priority of right as those ditches constructed for the purpose of utilizing the water of running streams: *Provided*, That the person upon whose land the seepage or spring waters first arise shall have the prior right to such waters if capable of being used upon his lands."

A number of acts have been passed at different times providing for the sinking of artesian wells at certain localities and appropriating money therefor.

IDAHO.

The rights relating to subterranean waters in Idaho are thus defined (L., 1899, p. 380, secs. 2 and 23):

"The right to the use of the waters of rivers, streams, lakes, ponds, and subterranean waters may be acquired by appropriation.

"All ditches now constructed, or which may hereafter be constructed, for the purpose of utilizing seepage, waste, or spring water of the State shall be governed by the same laws relating to priority of right as those ditches, canals, and conduits constructed for the purpose of utilizing the waters of running streams."

MICHIGAN.

In the State of Michigan the question of well interference is dealt with as follows:

"No person or persons, or corporation other than municipal corporations, owning or operating any artesian well, shall allow the same to flow a larger stream than will flow through a pipe 1 inch in diameter, to the detriment or injury of any other well or wells, without the consent of the owners of such well or wells so injured.

"Any person or persons who shall suffer any damage because of the violations of the provisions of this act shall be entitled to recover the same from the person or persons or corporations so causing the same, the action of trespass or the case to be brought in any court of competent jurisdiction.

"This act shall not apply to salt, oil, mineral water, or gas wells, or wells leased for bath purposes." (L., 1889, p. 221.)

NEBRASKA.

In 1897 the following act was passed "to prohibit the needless waste of mutual artesian water in the State of Nebraska" (L., 1897, p. 358, chap. 84, secs. 1–3):

"That it shall be unlawful for the owner or owners, lessee or lessees, occupier or occupiers, foreman or superintendent of any farm, town lot, or other real estate in the State of Nebraska where artesian water has been found, or may be found hereafter, to allow the water from wells or other borings or drillings on any farm, town lot, or other real estate in Nebraska to flow out and run to waste in any manner to exceed what will flow or run through a pipe one-half of one inch in diameter, except where the water is first used for irrigation, or to create power for milling or other mechanical purposes.

"Any person or persons who own, occupy, or have control of any farm, town lot, or other real estate in the State of Nebraska who fail or refuse to shut off the wastage of artesian water to the amount that this act allows on any farm, town lot, or other real estate which they own, occupy, or have control of, after being notified in writing by any person having the benefit of said mutual water supply, within forty-eight hours after such notification, shall be subject to arrest and, upon conviction, be fined in any sum not less than ten nor more than twenty-five dollars, and pay the costs of such arrest and prosecution

for each offense; and if such wastage be not abated within twenty-four hours after such arrest and conviction, it shall be deemed a second offense against the provisions of this act and be subject to the same fine as for the first offense, and each like offense or neglect of each twenty-four hours thereafter shall be deemed and constitute an additional offense against the provisions of this act.

"All prosecutions under the provisions of this act shall be brought by any person in the name of the State of Nebraska against any person or persons violating any of the provisions of this act, before any justice of the peace of the county in which such violation is alleged to have taken place, or before any court of competent jurisdiction."

NEVADA.

In order to encourage the search for artesian waters in the State of Nevada, several acts and amendments thereto have been passed providing bounties for those who sink artesian wells. Thus it is provided that the party sinking an artesian well, where flowing water in a specified quantity is obtained, shall receive the following bounties: For the first 200 feet, $1.25 per foot; for the third 100 feet, $1.50 per foot; for the fourth 100 feet, $2 per foot; and so on, up to $4.50 per foot for the tenth 100 feet; and for all depth exceeding 1,000 feet $5 per foot for each and every foot below the said 1,000 feet; together with an additional bounty of $1,000 for each well sunk to a depth of 1,000 feet or more. Certain conditions relating to the number of wells allowable within a given area, the amount of water required, and the persistence of flow, are prescribed.

Under certain prescribed conditions a bounty of $2,500 is offered to the person who first sinks a well in the State of Nevada, not less than 6 inches in diameter at the bottom, to a depth of 1,000 feet, said well flowing at least 60 gallons of water per minute.

A person engaged in the sinking of an artesian well upon any unoccupied public lands subject to selection by the State of Nevada, according to certain specified requirements, shall have a preferred right to all the lands he or she may be entitled to purchase under the provisions of certain acts providing for the selection and sale of the public lands of the State.

NEW JERSEY.

In 1904 an act (L., 1904, chap. 77, p. 188) was passed in New Jersey which empowered cities acquiring their water supply from artesian wells to improve and enlarge that supply, as follows:

"It shall and may be lawful for the governing board of any city now or hereafter acquiring its water supply from artesian wells, whenever in their judgment they shall deem it expedient to do so, to cause to be constructed an additional pipe line or main to connect

such water supply with any distributing reservoir within such city or with water-supply pipes or mains to any point within such city, and to dig and construct artesian wells, and to purchase and erect and to set up meters, machinery, and other fixtures in connection with and for the improvement of the water supply and waterworks plant of such city and to purchase and condemn land, waters, and rights, and otherwise to improve, enlarge, and extend said water supply and waterworks plant of such city, provided, however, that all such works shall be done and constructed by contract after public bidding therefor, in the manner prescribed in the laws now governing such city."

NEW MEXICO.

An act passed in 1897 authorizes any county in the Territory to issue and sell bonds for the purpose of sinking artesian wells. It states (L., 1897, chap. 66, sec. 2) that "the object of said wells shall be to ascertain whether flowing water can be procured on lands at present considered beyond and above the water belt—that is, above and beyond the belt wherein it has been demonstrated that flowing water can be obtained, and to encourage the boring of such wells for the purpose of increasing the area and productiveness of our agricultural lands and to reclaim high mesa lands which are now valueless for agricultural purposes."

By an act approved in 1903 the superintendent of the New Mexico penitentiary was authorized to provide for the drilling of an experimental well on land belonging to the penitentiary.

OKLAHOMA.

The laws of Oklahoma have definitely embodied the general principles upon which the common-law decisions relating to the different rights in underground and surface waters are based. Thus it is stated (Revised and Annotated Statutes, 1903, chap. 65, Property, art. 3): "The owner of the land owns water standing thereon or flowing over or under its surface, but not forming a definite stream. Water running in a definite stream formed by nature over or under the surface may be used by him so long as it remains there, but he may not prevent the natural flow of the stream or of the natural spring from which it commences."

OREGON.

The rights to seepage and spring waters in the State of Oregon are thus stated (L., 1893, p. 150): "All ditches now constructed, or hereafter to be constructed, for the purpose of utilizing the waste, spring, or seepage waters of the State shall be governed by the same laws relating to priority of right as those ditches constructed for the pur-

pose of utilizing the waters of running streams: *Provided*, That the person upon whose lands the seepage or spring waters first arise shall have the right to the use of such waters."

SOUTH DAKOTA.

A great deal of legislation has been enacted in South Dakota concerning artesian wells, especially acts providing for the sinking of such wells, defining the rights and liabilities of those who do sink them or who have control of them, and providing for the levying of taxes and the issuing of bonds to pay the necessary expenses. Those sections referring to official duties, the levying of taxes, etc., are not here considered, only the sections dealing more directly with subterranean waters being cited.

By a series of acts (L., 1889, chap. 14; 1890, chap. 103; 1891, chap. 80; 1893, chap. 109; 1895, chaps. 103, 106, 107, 108; 1897, chap. 74; 1903, chaps. 63, 64) and amendments thereto, it is provided that artesian wells may be sunk and watercourses be constructed therefrom upon petition of a majority of the qualified electors of any township in which the wells and the lands benefited thereby may be located; and that county, township, and special taxes may be levied to pay the cost of such wells and watercourses. Or any person or persons, corporation or company may construct artesian wells upon lands leased by them, and construct watercourses therefrom, the proprietors of such wells bearing the expense in proportion to their several interests. Certain restrictions are made regarding the number and location of waterways constructed from the wells, and the rights of parties controlling such waterways, of parties whose lands are crossed by them, and of the public are defined.

"All subterranean waters in the State of South Dakota may be used for irrigation, mechanical, and domestic purposes," according to the provisions stated in the several acts. One such provision requires the keeping of well records, as follows:

"It is hereby made the duty of the township board to embody in the contract for the sinking of said public artesian wells a proviso that the person sinking said wells shall make a record of the depth of each well and the formations entered or passed through in the construction of the same, and such provision is hereby made an essence of the contract and a violation thereof shall be construed to be a violation of the contract." (L., 1891, chap. 80, sec. 35.)

The danger of "well interference" is recognized, and certain provisions made for avoiding the trouble, so far as is practicable. Thus it is provided (L., 1891, chap. 80, sec. 42) that "Any person, association, or corporation owning land shall have the right to sink or bore an artesian well or wells on his, their, or its lands, for the purpose of procuring water for domestic use, for irrigation, or for manufactur-

ing purposes; but in wells hereafter constructed no more water shall be appropriated by such person, association, or corporation than is needed for said purposes, when such additional use of water interferes with the flow of wells on adjacent lands."

It has already been pointed out, in the first part of this report, that well interference may be foreseen and prevented to a greater or less extent by proper distribution of the wells. The decisions of the common law are in part based on the erroneous principle that it is impossible for any man to know until after his well is completed whether or not it will affect the flow of his neighbor's well. The State of South Dakota recognizes the possibility of foreseeing and preventing well interference, and deals with the question in the following manner:

"In locating wells in townships which have established and put down wells under the provisions of this act for public use or by private parties, due regard shall be had to their proper distribution, in order that the flow of the wells may be properly equalized and least likely to interfere with each other. Should any well in such township, public or private, be located so near any well already completed or in process of completion as to be likely to interfere with the same, any person may complain in writing to the State engineer, who shall without delay proceed to examine the locality and determine from its topography and the proximity of the wells whether, in his judgment, the wells as located would unduly interfere with the one already completed or in course of completion. If in his judgment there will be no material interference, the location will not be changed, but if in his opinion the well as located will materially interfere with the one completed or in course of completion he shall change the location of said well to some more suitable locality; provided, that when permanent buildings have been located on any farm prior to the sinking of any artesian well on any adjoining farm, this act shall not be construed as prohibiting the agent or proprietor of said farm from sinking an artesian well at or near said building without reference to the proximity of any other artesian well. The State engineer shall, within five days after said examination, make a written statement of his decision and file the same or a copy thereof in the office of the circuit court of the county wherein the said wells are located. Any person aggrieved by the decision of the State engineer may, within ten days after the filing of the decision in the office of the clerk of the circuit court, appeal from the same to the circuit court and upon such appeal the question shall be tried de novo." (L., 1891, chap. 80, sec. 43.)

In order to determine whether the amount of water flowing from an artesian well is increasing or decreasing, the State engineer is

required " to measure or to cause to be measured the flow and pressure of all artesian wells established and put down under the provisions of this act, public and private, at such times as he may deem proper, for the purpose of determining the increase or diminution of the flow or pressure of said well, and is hereby authorized to enter upon any grounds for the purposes aforesaid, and the owner or owners of such well or wells are hereby directed to furnish the necessary material to construct a suitable weir to measure the flow, and all reasonable conveniences shall be afforded for this purpose." (L., 1891, chap 80, sec. 44.)

Every person sinking an artesian well is required to provide for such well a proper casing, in order to prevent the well from caving in and to prevent the escape of the water when it is desirable that such water be confined; and he is further required to provide such valve and appliances as will enable him to control the flow of the water from the well. Concerning the wasting of artesian waters, it is provided (L., 1891, chap. 80, sec. 46) that: " No person controlling an artesian well shall suffer or permit the water therefrom to flow to waste unless and so far as reasonably necessary to prevent obstruction thereof, or to flow or to be taken therefrom save for beneficial uses: *Provided*, This shall not be so construed as to prevent the reasonable use of said water for the necessary irrigation of trees standing along or upon any street, road, or highway, or for ornamental ponds or fountains, or the propagation of fish."

If any person complains that the proprietor of an artesian well, or the party controlling such well, is in the habit of letting the waters go to waste, the township supervisor, county commissioner, road overseer, alderman, or other city officers may enter upon the premises where the well is located in order to determine whether the complaint is justified, and may institute criminal prosecution in case violation of the law is ascertained. If the well is without valves to regulate the flow and prevent waste, the person owning the well may be fined up to one hundred dollars or be imprisoned not more than three months in jail, or both.

The flow of water through a watercourse from any artesian well is not to be interfered with, it being the duty of every person through whose land such a watercourse runs to keep the same open and unobstructed. The road overseer must keep such watercourses along a public highway clear. It is further provided (L., 1893, chap. 109, sec. 32) that: "All natural watercourses in this State, whenever an artesian well is located thereon under the provisions of this act, are hereby created and declared public natural watercourses for the flow of water from such artesian wells for the benefit of the public and of

private individuals located on such watercourses, subject only to compensation for damages as in this act provided."

UTAH.

"The waters of all streams and other sources in this State, whether flowing above or underground in known or definite channels, are hereby declared to be the property of the public, subject to all existing rights to the use thereof." (L., 1903, chap. 100, sec. 47.)

WASHINGTON.

In the State of Washington the rights to seepage and spring waters are thus defined:

"All ditches now constructed or hereafter to be constructed for the purpose of utilizing the waste, seepage, or spring waters of the State shall be covered by the same laws as those ditches constructed for the purpose of utilizing the water of natural streams and lakes: *Provided*, That the person upon whose land the seepage or spring waters first rise shall have a prior right to such waters, if capable of being used upon his lands." (L., 1890, p. 710, sec. 15.)

In 1901 an act was passed "in relation to artesian wells and regulating the flow of waters therefrom; and providing a penalty for the violation thereof." (L., 1901, p. 259, sec. 1–4.) The text of this act is given in full:

"It shall be unlawful for any person, firm, corporation, or company having possession or control of any artesian well within the State, whether as contractor, owner, lessee, agent, or manager, to allow or permit water to flow or escape from such well between the first day of October in any year and the first day of April next ensuing: *Provided*, That this act shall only apply to sections and communities wherein the use of water for the purposes of irrigation is necessary or customary: *And provided further*, That nothing herein contained shall prevent or prohibit the use of water from such well between the first day of October and the first day of April next ensuing for household, stock, and domestic purposes only, water for the last-named purposes to be taken from such well through a one-half inch stop and waste cock to be inserted in the piping of such well for that purpose.

"It shall be the duty of every person, firm, corporation, or company having possession or control of any artesian well as provided in section 1 of this act to securely cap the same over, on or before the first day of October in each and every year, in such manner as to prevent the flow or escape of water therefrom, and to keep the same securely capped and prevent the flow or escape of water therefrom until the first day of April next ensuing: *Provided, however*, It shall and may be lawful for any such person, firm, corporation, or company to insert

a one-half inch stop and waste cock in the piping of such well and to take and use water therefrom through such stop and waste cock at any time, for household, stock, and domestic purposes, but not otherwise.

"Any person, whether the owner, lessee, agent or manager, having possession of any such well, violating the provisions of this act shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be fined in any sum not exceeding two hundred dollars for each and every such offense, and the further sum of two hundred dollars for each ten days during which such violation shall continue.

"Whenever any person, firm, corporation, or company in possession or control of an artesian well shall fail to comply with the provisions of this act, any person, firm, corporation, or company lawfully in possession of the land adjacent to or in the vicinity or neighborhood of such well, and within five miles thereof, may enter upon the land upon which such well is situated and take possession of such, from which water is allowed to flow or escape in violation of the provisions of section 1 of this act, and cap such well and shut in and secure the flow or escape of water therefrom, and the necessary expense incurred in so doing shall constitute a lien upon said well, and a sufficient quantity of land surrounding the same, for the use and operation thereof, which lien may be foreclosed in a civil action in any court of common jurisdiction, and the court in any such case shall allow the plaintiff a reasonable attorney's fee, to be taxed as a part of the cost. This shall be in addition to the penalty provided for in section 3 of this act."

WISCONSIN.

In the State of Wisconsin the questions of well interference and the wasting of artesian waters are thus dealt with:

"Where there are two or more artesian wells in any vicinity or neighborhood, one or more of which are operated or used by any person or owner, the person or owner of such well shall use due care and diligence to prevent any loss or waste or unreasonable use of the water therein contained or flowing from the same, as would deprive or unnecessarily diminish the flow of water in any artesian well, to the injury of the owner of any other well in the same vicinity or neighborhood.

"Any person who shall needlessly allow or permit any artesian well owned or operated by him to discharge greater quantities of water than is reasonably necessary for the use of such person, so as to materially diminish the flow of artesian water in any other well in the

same vicinity, shall be liable for all damages which the owner of any such other well shall sustain." (L., 1901, chap. 354.)

WYOMING.

According to the provisions of an act (L., 1888, chap. 19) passed in 1888, the boards of county commissioners of the several counties in the State of Wyoming are authorized to provide for the sinking of artesian wells at various places within such counties; and where the nature of the country makes an artesian well impracticable, tanks, reservoirs, etc., may be constructed. Certain restrictions are imposed, the rights and duties of private citizens and officials are defined, and appropriation of money is authorized.

INDEX.

A.

Page.

Abbreviations, use of ---------- 7–8
Acme Oil Co., Dillon v. *See* Dillon v. Acme Oil Co.
Acton v. Blundell, decision in, on percolating waters --- 13–14
decision in, on well interference ---------- 15
Agreements, effect of ---------- 30–31, 34
strict construction of ---------- 31
Alexander v. United States, decision in, on well interference ---------- 17
Alston v. Grant, decision in, on pollution ---------- 26
American and English Encyclopedia of Law: Underground Waters, citations from- 7
Angell, J. K., on nature of property in percolating water-- 36
Appropriation, prior, establishment of ---------- 12
laws concerning----- 41–42, 44–45, 48
Arid and humid States, different rules in ------ 20–21, 32–33

B.

Ball v. Nye, decision in, on pollution ---------- 26
Ballacorkish Mining Co. v. Harrison, decision in, on agreements ---------- 30
v. Dumbell, decision in, on well interference -------- 15
Ballard v. Tomlinson, decision in, on pollution ---------- 25, 26
Barrows, J., decision of, on motives- 30
Bartlett, J., decision of, on well interference ---------- 16
Barnard v. Shirley, decision in, on disposal of intercepted water ---------- 22
decision in, on pollution------- 27–28
Bassett v. Salisbury Mfg. Co., decision in, on well interference ---------- 16
decision in, on damming underground water-------- 21
Baugh, Wheatley v. *See* Wheatley v. Baugh.
Bellows, C. J., decision of, on motive ---------- 30
Bennett, E. H., on pollution-------- 25
Benton, Harwood v. *See* Harwood v. Benton.
Black, J., decision of, on motives--- 29
Blundell, Acton v. *See* Acton v. Blundell.
Boston and Maine R. R., Parker v. *See* Parker v. Boston and Maine R. R.
Braintree Water Supply Co., proprietors of Mills v. *See* Proprietors of Mills v. Braintree Water Supply Co.
Brett, M. R., decision of, on pollution ---------- 26
Brinkerhoff, J., on public policy and rights in percolating water ---------- 14
on motive---------- 29
on prescription---------- 32
Brookline, Trowbridge v., decision in, on well interference -- 16–17
Brooklyn, Smith v. *See* Smith v. Brooklyn.
Brown, Strait v. *See* Strait v. Brown.
Brown v. Illius, decision in, on pollution---------- 27
Brown, Frazier v. *See* Frazier v. Brown.

C.

California, common-law decisions in- 16, 18, 19, 20–21, 32–33, 38, 39
statute laws of---------- 39–40
Case v. Hoffman, decision in, on existence of underground streams ---------- 10
Cemeteries, damage from---------- 26
Channels, underground, defined and known, definition of -- 10
See also Streams, underground.
Chasemore v. Richards, decision in, on stream-supply interference ---------- 19
Chartiers V. Gas Co., Collins v. *See* Collins v. Chartiers V. Gas Co.
Chauvet v. Hill, decision in, on spring interference --- 18
Chesley v. King, decision in, on motives ---------- 30
Church, Womersley v. *See* Church v. Womersley.

Page.

Clark *v.* Lawrence, decision in, on pollution ---------- 26
Collins, Pickard *v.* *See* Pickard *v.* Collins.
Collins *v.* Chartiers V. Gas Co., decision in, on precedents ---------- 35
Colorado, statute laws of---------- 40–41
Coloring matter, underground transmission of, proofs by-- 11
Connecticut, common-law cases in -- 27
Cooley, J., decision of, on pollution- 27
Corporations, status of, in regard to percolating water- 16–18, 32
Cronin, Walker *v.* *See* Walker *v.* Cronin.
Crops, injury to, by abstraction of percolating water---- 19–21
Cutts, Swett *v.* *See* Swett *v.* Cutts- 30

D.

Damming streams, right of-------- 12
Damming underground water, damages from ---------- 21, 33
Dickinson *v.* Grand Junction Canal Co., decision in, on stream-supply interference ---------- 19
Dillon *v.* Acme Oil Co., decision in, on pollution --------- 27
Ditches. *See* Sewers.
Draining land, damages to water supply from ---------- 17–18
Dufour, Southern Pacific R. R. Co. *v.* *See* Southern Pacific R. R. Co. *v.* Dufour.
Dumball, Ballacorkish Mining Co. *v.* *See* Ballacorkish Mining Co. *v.* Dumball.
Durham, Porter *v.*, on motives----- 29

E.

Elster *v.* Springfield, decision in, on spring interference--- 18
Excavating, damages to water supply from------ 16–18, 27, 32

F.

Fall River Iron Works Co., Sherman *v.* *See* Sherman *v.* Fall River Iron Works Co.
Farmer, Stillwater Water Co. *v.* *See* Stillwater Water Co. *v.* Farmer.
Fletcher, Rylands *v.* *See* Rylands *v.* Fletcher.
Forbell *v.* New York, decision in, on injury to land ------- 20
Fowler, Jenkins *v.* *See* Jenkins *v.* Fowler.

Page.

Frazier *v.* Brown, decision in, on public policy and rights in percolating water-- 14
decision in, on motives-------- 29
on prescription---------- 32

G.

Gas refuse, pollution by---------- 25–27
Gould, J. M., Law of Waters by, citations from---------- 7
definition by---------- 10
on agreements ---------- 30–31
on artificial percolation ------- 24
on damming underground waters ---------- 21
on disposal of intercepted waters ---------- 22–24
Grand Junction Canal Co., Dickenson *v.* *See* Dickinson *v.* Grand Junction Canal Co.
Grand Junction Canal Co. *v.* Shugar, decision in, on artificial percolation ------ 23
Grant, Alston *v.* *See* Alston *v.* Grant.
Grants. *See* Agreements.
Gray, John C., acknowledgments to- 7
Greencastle *v.* Hazelett, decision in, on pollution --------- 26
Ground, imperfect support of, damage to water supply from ---------- 18
Gumbert *v.* Kilgore, decision in, on spring interference --- 18

H.

Harrison, Ballacorkish Mining Co. *v.* *See* Ballacorkish Mining Co. *v.* Harrison.
Hart *v.* Jamaica Pond Aqueduct Co., decision in, on well interference ---------- 16
Harwood *v.* Benton, decision in, on damming underground water ---------- 21
Hathesly, Lord, L. C., decision of, on artificial percolation-- 23
Hazelett, Greenfield *v.* *See* Greenfield *v.* Hazelett.
Hill, Chauvet *v.* *See* Chauvet *v.* Hill.
Hoffman, Case *v.* *See* Case *v.* Hoffman.
Hougan *v.* Milwaukee and St. Paul R. R. Co., decision in, on well interference -- 17

I.

Idaho, statute laws of ---------- 41–42
Illinois, common-law cases in ------ 27
Illius, Brown *v.* *See* Brown *v.* Illius.
Indiana, common-law cases in------ 22, 28

Page.

Injunctions, granting of ---------- 26
Iowa, common-law decision in ------ 16, 17

J.

Jacobs, Wheelock *v.* *See* Wheelock *v.* Jacobs.
Jamaica Pond Aqueduct Co., Hart *v.* *See* Jamaica Pond Aqueduct Co. *v.* Hart.
Jenkins *v.* Fowler, decision in, on motive ---------- 29
Johnson, New River Co. *v.* *See* New River Co. *v.* Johnson.
Johnstown Cheese Mfg. Co. *v.* Veghte, decision in, on agreements --------- 31

K.

Katz *v.* Walkinshaw, decision in, on well interference ----- 16, 20–21, 32–33, 38, 39
Kentucky, common-law cases in ---- 25
Kenyon, West Cumberland Iron Co. *v.* *See* West Cumberland Iron Co. *v.* Kenyon.
Kilgore, Gumbert *v.* *See* Gumbert *v.* Kilgore ---------- 18
King, Chesley *v.* *See* Chesley *v.* King.
Kinnaird *v.* Standard Oil Co., decision in, on pollution 25

L.

Land, damages to, from interference with percolating water ---------- 19–21, 33
Land, drainage of, damages to water supply by ------ 30
Law, common, on underground waters ---------- 9–38
Law, statute, on underground waters ---------- 39–49
Lawrence, Clark *v.* *See* Clark *v.* Lawrence.
Lawyer's Reports Annotated, citations from ---------- 7
Lewis, C. J., decision of, on indefinite character of percolating water ------- 14
decision of, on motives -------- 29
on spring interference ---- 18

M.

Martinsville, Skaggs *v.* *See* Skaggs *v.* Martinsville.
Massachusetts, common-law decisions in 12, 16, 17, 23, 26, 29
Metropolitan Board of Works, Regina *v.* *See* Regina *v.* Metropolitan Board of Works.
Michigan, statute laws of --------- 42

Page.

Milwaukee and St. Paul R. R. Co., Hougan *v.* *See* Hougan *v.* Milwaukee and St. Paul R. R. Co.
Mines, damages to water supply from ---------- 15, 23
flooding adjacent mines by water from ------- 21, 22–24
Mirfield, Turner *v.* *See* Turner *v.* Mirfield.
Mitchell, J., on progress of geological knowledge ---- 35
Motive, immateriality of ---- 24, 28–29, 33
materiality of ---------- 27, 30, 33

N.

Nebraska, statute laws of --------- 42–43
Negligence, effect of ---------- 24, 27, 28
Nevada, bounties for artesian wells in ---------- 43
common-law decisions in ------ 19
statute laws of ---------- 43
New Albany and Salem R. R. Co. *v.* Peterson, decision in, on well interference -- 17
New Hampshire, common-law decisions in ------- 15–16, 21, 22
New Jersey, statute laws of ------- 43–44
New Mexico, statute laws in ------- 44
New River Co. *v.* Johnson, decision in, on well interference ---------- 15
New York, common-law cases in ---- 20, 27, 29, 31
New York, Forbell *v.* *See* Forbell *v.* New York.
Nowlen, Phelps *v.* *See* Phelps *v.* Nowlen.
Nye, Ball *v.* *See* Ball *v.* Nye.

O.

Ohio, common-law decisions in -- 17, 18, 29
Oil, pollution by ---------- 25
Oklahoma, statute laws of --------- 44
Oregon, statute laws of ---------- 44–45

P.

Parker *v.* Boston and Maine R. R., decision in, on well interference ---------- 16
Pennsylvania, common-law decision in ---------- 14, 23, 29, 35
Percolating water, court precedents concerning ---------- 34–35
damming of, damage from ----- 21, 33
distinction between other real estate and ---------- 36–38
distinction between surface streams and ------ 11–13, 32
existence of, presumption in favor of ---------- 9, 10
interference with, damages from ---------- 13–31
knowledge of ---------- 9, 34–38

Page.

Percolating water, lack of agreement concerning ---------- 34, 38
legal rights in ---------- 12–31
ownership in ---------- 13, 32, 36
pollution of ---------- 25–28, 33, 36
priority of use of---- 41–42, 44–45, 48
public policy and rights in----- 14
sale of, right of-- 16, 20–21, 32–33, 37
waste of ---------- 18
Percolating waters, intercepted, disposal of---------- 21–22, 33
Percolation, artificial production of ---------- 22–24, 33
Perry, Willis *v.* *See* Willis *v.* Perry.
Peterson, New Albany and Salem R. R. Co. *v.* *See* New Albany and Salem R. R. Co. *v.* Peterson.
Phelps *v.* Nowlen, decision in, on motive ---------- 29
Pickard *v.* Collins, decision in, on motive ---------- 29
Pollution of underground water, liability for ---------- 25–28
Pollution, motive of---------- 27, 28, 33
Pomeroy, J. N., Water Rights by, citations from ------- 7
Porter *v.* Durham, decision in, on motive ---------- 29
Prescription, nonapplicability of- 31–32, 34
Privies, damage from---------- 26–27
Proprietors of Mills *v.* Braintree Water Supply Co., decision in, on artificial percolation ---------- 23
Public policy, rights in percolating water and---------- 14

R.

Reasonable use of percolating waters, decisions concerning -- 15–16, 20, 22, 28, 32, 33
Regina *v.* Metropolitan Board of Works, decision in, on interference with springs ---------- 17
Reinbach, Wahle *v.* *See* Wahle *v.* Reinbach.
Reservoir, percolation from, damages by ---------- 23–24
Richards, Chasemore *v.* *See* Chasemore *v.* Richards.
Richland Township Co., Upjohn *v.* *See* Upjohn *v.* Richland Township Co.
Rocks, structural relations of, proofs of underground channels from---------- 10
Rodman, J., decision in, on motive-- 29
Rylands *v.* Fletcher, decision in, on artificial percolation -- 24
decision in, on pollution of underground water ----- 25

S.

Page.

Salisbury Mfg. Co., Bassett *v.* *See* Bassett *v.* Salisbury Mfg. Co.
Sewage, pollution by---------- 25, 26
Sewers, construction of, damage to water supply by--- 16–19, 32
Sherman *v.* Fall River Iron Works Co., decision in, on pollution ---------- 26
Shirley, Barnard *v.* *See* Barnard *v.* Shirley.
Shugar, Grand Junction Canal Co. *v.* *See* Grand Junction Canal Co. *v.* Shugar-- 23
Sink holes, proof of underground channel furnished by- 10
Skaggs *v.* Martinsville, decision in, on disposal of intercepted waters-------- 22
Smith *v.* Brooklyn, decision in, on stream-supply interference ---------- 19
Solid matter, underground transmission of, proofs furnished by ---------- 10
Southern Pacific R. R. Co. *v.* Dufour, decision in, on spring interference --- 17–19
Springfield, Elster *v.* *See* Elster *v.* Springfield ---------- 18
Springs, grant of, implications of--- 18, 31
interference with---------- 17–18
streams from, riparian rights on ---------- 18, 19
Standard Oil Co., Kinnaird *v.* *See* Kinnaird *v.* Standard Oil Co.
Stillwater Water Co. *v.* Farmer, decision in, on spring interference ---------- 18
Strait *v.* Brown, decision in, on stream-supply interference ---------- 19
Streams, surface, distinction between percolating waters and ---------- 11–13, 32
legal identity of underground streams and------ 11, 27, 32
legal rights in and limitations on ---------- 11–12, 18
percolating water supply for, interference with ---- 18–19, 22–23, 33
Streams, underground, distinction between percolating waters and------- 11–13, 32
legal identity of surface streams and ---------- 11, 27
presumption against existence of 9–10
proofs of existence of---------- 10–11
Strong, T. R., decision of, on motive ---------- 29
Swett *v.* Cutts, decision in, on motive ---------- 30

T. Page.

Temple, J., on nature of property in percolating water ---- 37
Tindal, C. J., on indefinite character of percolating water-- 13–14
Tomlinson, Ballard *v.* *See* Ballard *v.* Tomlinson.
Transmission, underground, proofs of channel furnished by ---------- 10
Trowbridge, *v.* Brookline, decision in, on well interference -- 16–17
Turner *v.* Mirfield, decision in, on pollution ---------- 26

U.

Underground water. *See* Water, underground.
United States, Alexander *v.*, decision in, on well interference ---------- 17
Upjohn *v.* Richland Township Co., decision in, on pollution ---------- 27
Utah, statute laws of ---------- 48

V.

Vault, percolating water from, damage by---------- 26
Veghte, Johnstown Cheese Mfg. Co. *v.* *See* Johnstown Cheese Mfg. Co. *v.* Veghte.
Vermont, common-law decisions in-- 18, 21

W.

Waddell, Wilson *v.* *See* Wilson *v.* Waddell.
Wahle *v.* Reinbach, decision in, on pollution ---------- 27

Page.

Walker *v.* Cronin, decision in, on motive ---------- 29
Walker, George A., acknowledgments to ---------- 7
Walkinshaw, Katz *v.* *See* Katz *v.* Walkinshaw -------- 16
Washington, statute laws of------- 48–49
Water, underground, classes and definition of --------- 9–10
See also Streams, underground; Percolating waters.
Wells, construction of, damages to other water supply from- 14–17, 19, 22–23, 30–33
interference with- 14–17, 32, 45–46, 49
Wells, artesian, bounties for drilling of ---------- 43
control of---------- 40
definition of ---------- 40, 41
flow from ---------- 46–47
records of---------- 40, 41, 45
streams from, riparian rights on---------- 47–48
statute laws on ---------- 39–50
water from, waste of---- 39–43, 47–49
disposal of ---------- 22, 27–28
pollution of ---------- 27–28
Wells, J., decision of, on motive---- 29
West Cumberland Iron Co. *v.* Kenyon, decision in, on intercepted water ---- 22
Wheatley *v.* Baugh, decision in, on spring interference --- 18
on motive ---------- 29
Wheelock *v.* Jacobs, decision in, on spring interference --- 18
Willis *v.* Perry, decision in, on well interference -------- 16
Wilson *v.* Waddell, decision in, on artificial percolation-- 24
Wisconsin, statute laws of--------- 49–50
Womersley *v.* Church, decision in, on pollution--------- 26
Wyoming, statute laws of --------- 50

O

PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Water-Supply Paper No. 122.]

The serial publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of United States—folios and separate sheets thereof, (8) Geologic Atlas of the United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

The Professional Papers, Bulletins, and Water-Supply Papers treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous; H, Forestry; I, Irrigation; J, Water storage; K, Pumping water; L, Quality of water; M, General hydrographic investigations; N, Water power; O, Underground waters; P, Hydrographic progress reports. This paper is the thirty-fifth in Series O, the complete list of which follows. (PP= Professional Paper; B=Bulletin; WS=Water-Supply Paper.)

SERIES O—UNDERGROUND WATERS.

WS 4. A reconnaissance in southeastern Washington, by I. C. Russell. 1897. 96 pp., 7 pls.
WS 6. Underground waters of southwestern Kansas, by E. Haworth. 1897. 65 pp., 12 pls.
WS 7. Seepage waters of northern Utah, by Samuel Fortier. 1897. 50 pp., 3 pls.
WS 12. Underground waters of southeastern Nebraska, by N. H. Darton. 1898. 56 pp., 21 pls.
WS 21. Wells of northern Indiana, by Frank Leverett. 1899. 82 pp., 2 pls.
WS 26. Wells of southern Indiana (continuation of No. 21), by Frank Leverett. 1899. 64 pp.
WS 30. Water resources of the Lower Peninsula of Michigan, by A. C. Lane. 1899. 97 pp., 7 pls.
WS 31. Lower Michigan mineral waters, by A. C. Lane. 1899. 97 pp., 4 pls.
WS 34. Geology and water resources of a portion of southeastern South Dakota, by J. E. Todd. 1900. 34 pp., 19 pls.
WS 53. Geology and water resources of Nez Perces County, Idaho, Pt. I, by I. C. Russell. 1901. 86 pp., 10 pls.
WS 54. Geology and water resources of Nez Perces County, Idaho, Pt. II, by I. C. Russell. 1901. 87-141 pp.
WS 55. Geology and water resources of a portion of Yakima County, Wash., by G. O. Smith. 1901. 68 pp., 7 pls.
WS 57. Preliminary list of deep borings in the United States, Pt. I, by N. H. Darton. 1902. 60 pp.
WS 59. Development and application of water in southern California, Pt. I, by J. B. Lippincott. 1902. 95 pp., 11 pls.
WS 60. Development and application of water in southern California, Pt. II, by J. B. Lippincott. 1902. 96-140 pp.
WS 61. Preliminary list of deep borings in the United States, Pt. II, by N. H. Darton. 1902. 67 pp.
WS 67. The motions of underground waters, by C. S. Slichter. 1902. 106 pp., 8 pls.
B 199. Geology and water resources of the Snake River Plains of Idaho, by I. C. Russell. 1902. 192 pp., 25 pls.
WS 77. Water resources of Molokai, Hawaiian Islands, by W. Lindgren. 1903. 62 pp., 4 pls.
WS 78. Preliminary report on artesian basin in southwestern Idaho and southeastern Oregon, by I. C. Russell. 1903. 53 pp., 2 pls.
PP 17. Preliminary report on the geolgy and water resources of Nebraska west of the one hundred and third meridian, by N. H. Darton. 1903. 69 pp., 43 pls.
WS 90. Geology and water resources of part of the lower James River Valley, South Dakota, by J. E. Todd and C. M. Hall. 1904. 47 pp., 23 pls.

WS 101. Underground waters of southern Louisiana, by G. D. Harris, with discussions of their uses for water supplies and for rice irrigation, by M. L. Fuller. 1904. 98 pp., 11 pls.

WS 102. Contributions to the hydrology of eastern United States, 1903, by M. L. Fuller. 1904. 522 pp.

WS 104. Underground waters of the Gila Valley, Arizona, by W. T. Lee. 1904. 68 pp., 5 pls.

WS 106. Water resources of the Philadelphia district, by Florence Bascom. 1904. 75 pp., 4 pls.

WS 110. Contributions to the hydrology of eastern United States, 1904; M. L. Fuller, geologist in charge. 1905. 211 pp., 5 pls.

PP 32. Geology and underground water resources of the central Great Plains, by N. H. Darton. 1905. 433 pp., 72 pls.

WS 111. Preliminary report on underground waters of Washington, by Henry Landes. 1905. 85 pp. 1 pl.

WS 112. Underflow tests in the drainage basin of Los Angeles River, by Homer Hamlin. 1905. 55 pp., 7 pls.

WS 114. Underground waters of eastern United States, by M. L. Fuller and others. 1905. 285 pp., 18 pls.

WS 118. Geology and water resources of east-central Washington, by F. C. Calkins. 1905. 96 pp., 4 pls.

B 252. Preliminary report on the geology and water resources of central Oregon, by I. C. Russell. 1905. 138 pp., 24 pls.

WS 120. Bibliographic review and index of papers relating to underground waters published by the United States Geological Survey, 1879–1904, by M. L. Fuller. 1905. 128 pp.

WS 122. Relation of the law to underground waters, by D. W. Johnson. 1905. 55 pp.

The following papers also relate to this subject: Underground waters of Arkansas Valley in eastern Colorado, by G. K. Gilbert, in Seventeenth Annual, Pt. II; Preliminary report on artesian waters of a portion of the Dakotas, by N. H. Darton, in Seventeenth Annual, Pt. II; Water resources of Illinois, by Frank Leverett, in Seventeenth Annual, Pt. II; Water resources of Indiana and Ohio, by Frank Leverett, in Eighteenth Annual, Pt. IV; New developments in well boring and irrigation in eastern South Dakota, by N. H. Darton, in Eighteenth Annual, Pt. IV; Rock waters of Ohio, by Edward Orton, in Nineteenth Annual, Pt. IV; Artesian well prospects in the Atlantic Coastal Plain region, by N. H. Darton, Bulletin No. 138.

Correspondence should be addressed to

THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, D. C.

APRIL, 1905.

LIBRARY CATALOGUE SLIPS.

[Mount each slip upon a separate card, placing the subject at the top of the second slip. The name of the series should not be repeated on the series card, but the additional numbers should be added, as received, to the first entry.]

Author.

Johnson, Douglas Wilson.

. . . Relation of the law to underground waters, by Douglas Wilson Johnson. Washington, Gov't print. off., 1905.

55, iii p. 23cm. (U. S. Geological survey. Water-supply and irrigation paper no. 122)

Subject series: O, Underground waters, 35.

1. Water—Laws and legislation. 2. Water, underground—U. S.

Subject.

Johnson, Douglas Wilson.

. . . Relation of the law to underground waters, by Douglas Wilson Johnson. Washington, Gov't print. off., 1905.

55, iii p. 23cm. (U. S. Geological survey. Water-supply and irrigation paper no. 122)

Subject series: O, Underground waters, 35.

1. Water—Laws and legislation. 2. Water, underground—U. S.

Series.

U. S. Geological survey.

Water-supply and irrigation papers.

no. 122. Johnson, D. W. Relation of the law to underground waters. 1905.

Reference.

U. S. Dept. of the Interior.

see also

U. S. Geological survey.

Water-Supply and Irrigation Paper No. 123

Series { B, Descriptive Geology, 66
{ O, Underground Waters, 36

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

GEOLOGY AND UNDERGROUND WATER CONDITIONS

OF THE

JORNADA DEL MUERTO, NEW MEXICO

BY

CHARLES ROLLIN KEYES

WASHINGTON
GOVERNMENT PRINTING OFFICE
1905

CONTENTS.

	Page.
Letter of transmittal	7
Introduction	9
General character of the New Mexican plateau region	11
Surface relief of the Jornada	13
General features	13
Central floor of the basin	14
Eastern rim of the basin	14
Western rim of the basin	15
Northern rim of the basin	17
Southern side of the basin	17
The formations	18
General geologic relations	18
Archean system	19
Algonkian system	19
Rocks of early Paleozoic age	20
Carboniferous system	20
Jurassic-Triassic systems	22
Cretaceous system	22
Tertiary and Quaternary systems	23
Eruptive rocks	24
Structure	25
General characteristics	25
Structural relations of the formations	26
Descriptions of cross sections	27
Some minor structural features	28
Underground waters	32
General consideration	32
Areal distribution of the water-bearing beds	33
Area of water supply	34
Climatic conditions affecting water supply	34
Permeable strata	34
Water horizons	35
Wells of the Jornada del Muerto	37
Quality of the underground waters	38
Résumé of underground water prospects	38
Irrigation	39
Index	41

ILLUSTRATIONS.

		Page.
PLATE I.	Geologic sketch map of the Jornada	10
II.	Cross section of the region, along the lines A-A, B-B, and C-C, Pl. I.	12
III.	*A*, View of northern end of the Jornada; *B*, Peña Blanca, the white cliffs at lower end of Organ Mountains	14
IV.	*A*, Escarpment of the Chupadera Mesa; *B*, Peñasco Rock	16
V.	*A*, Elephant Butte, view taken from big bend in Rio Grande; *B*, Soledad Canyon, a mountain arroyo	18
VI.	*A*, Organ Mountains, New Mexico, showing break off or change in topography; *B*, View showing location of canal line running along small ridges directly back of Agricultural College	20
VII.	*A*, International reservoir site, 2½ miles above international dam site; *B*, River bed at international reservoir site, view taken from big bend in river	22
VIII.	Topography of the Fort Selden eruptive area	24
IX.	*A*, Organ Mountains, New Mexico, showing a portion of the mountains; *B*, Natural dike near Elephant Butte	26
FIG. 1.	Location of the Jornada del Muerto	9
2.	Geologic column	18
3.	Mescal cone, resting on Cretaceous sandstones	25
4.	Basin Range structure of the Jornada	26
5.	Small reversed fault in western rim of Jornada	29
6.	Caballos Peak and thrust plane	29
7.	Normal faulting at Napoleon mine	30
8.	Normal faulting at El Capitan mine	30
9.	Basic dike in Cretaceous sandstone	31
10.	Basic dike disturbing level sandstones	31
11.	Acidic dike in Carboniferous limestones	32

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
HYDROGRAPHIC BRANCH,
Washington, D. C., July 15, 1904.

SIR: I transmit herewith a report by Prof. Charles R. Keyes on the geology and underground water resources of the Jornada del Muerto, in south-central New Mexico, and recommend that it be published in the series of Water-Supply and Irrigation Papers.

The work resulting in this report was done under the supervision of Mr. N. H. Darton, chief of the western section of the division of hydrology. It presents new and valuable information regarding the geologic structure of this large desert area and shows that the conditions are favorable for the extensive occurrence of underground waters which, to some extent, are available for irrigation and domestic supplies. The region is one of fine climate and fertile soil, and the development of its underground waters will afford the means for sustaining settlers at a number of localities.

Very respectfully,

F. H. NEWELL,
Chief Engineer.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

GEOLOGY AND UNDERGROUND WATER CONDITIONS OF THE JORNADA DEL MUERTO, NEW MEXICO.

By CHARLES ROLLIN KEYES.

INTRODUCTION.

Of the basin plains of southwestern United States the Jornada del Muerto, in south-central New Mexico, is, in many ways, one of the most

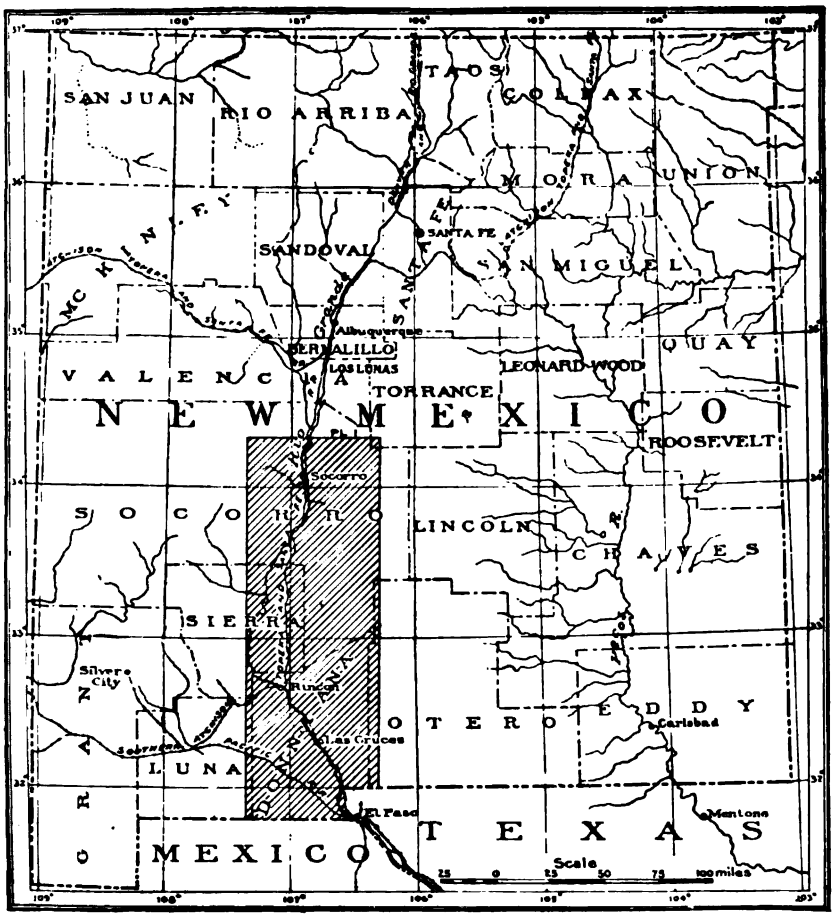


FIG. 1.—Location of the Jornada del Muerto.

remarkable. This plain is typical of a very large number of dry sandy plains which characterize the arid region and which show but

few signs of surface waters. As it is covered by loose, porous soils of unknown depth all the rainfall is quickly absorbed and the streams entering the plain from the mountains around the periphery soon sink below the surface.

In the long period that preceded the coming of the European the adjoining country was thickly populated by races highly skilled in agriculture and well trained in the art of irrigation, yet no one of the native peoples was tempted to settle upon this great strip of desert. For three hundred and fifty years after the Spanish invasion the Jornada lay in the beaten path of travel from Mexico northward. For 100 miles the famous El Paso and Santa Fe trail crossed its desert sands. In view of the horrors inspired by the trip across it from the time of Coronado to the advent of the railroad, the Spaniards who ventured within its borders might well be pardoned for calling it the "Journey of Death." The long white line of bleached bones of man and horse, which not so very long ago marked the trail, amply attested the fitness of the title.

Wallace[a] has described the Jornada in very somber though highly fanciful terms as follows:

> Near the southern boundary of New Mexico the Spanish explorers were opposed by a barrier of all on earth most to be dreaded—a shadeless, waterless plateau nearly 100 miles long, from 5 to 30 miles wide, resembling the steppes of northern Asia. * * *
>
> The portion I speak of appears to have served its time, worn out, been dispeopled, and forgotten. The grass is low and mossy, with a perishing look—the shrubs, soapweed, and bony cactus writhing like some grisly skeleton; the very stones are like the scoria of a furnace. You vainly look for the flight of a bird, such as cheered the eyes of Thalaba in the desert; no bee nor fly hums in the empty air; and, save the lizard (the genius of desolation) and horn frog, there is no breath of living thing.
>
> Standing on the edge of the measureless waste, which is trackless as water, the first explorers might ask, "What is this strange ocean of sand, with its stillness more awful than any sea?"
>
> The spot I am trying to describe is the battle ground of the elements. In winter it is made fearful by raging storms of wind and snow. There men and animals have been frozen to death, their bodies left the lawful prey of the mountain wolf. From the primeval years the Apache has harried the hungry waste, hunting for scalps and, besides the savagest of savages, it is now the favorite skulking [illegible] an asylum for fugitives escaping justice in old Mexico and Texas.
>
> In our times many a party cut off and many a traveler murdered [illegible] name it bears, given by the first white men who dared its perils, [illegible] "Journey of Death."

Repulsive as this picture is, it scarcely [illegible] impression which formerly existed [illegible] much of the arid region, this distinction [illegible] no water appears on the surface [illegible] the traveler traversed this region [illegible] beneath the surface of the plain [illegible]

[a] Wallace, S. E., Lan[illegible]

few signs of surface waters. As it is covered by loose, porous soils of unknown depth all the rainfall is quickly absorbed and the streams entering the plain from the mountains around the periphery soon sink below the surface.

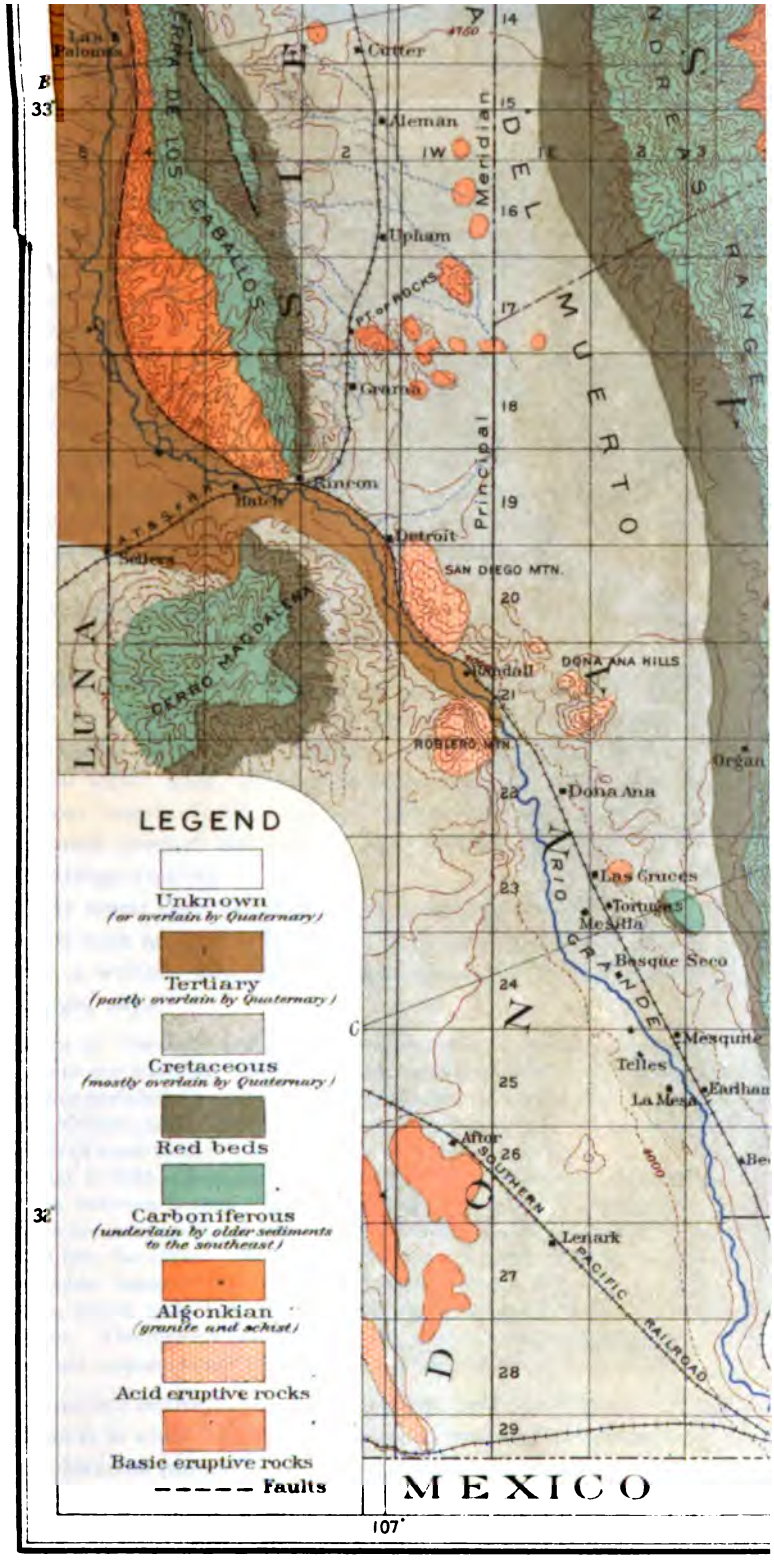
In the long period that preceded the coming of the European the adjoining country was thickly populated by races highly skilled in agriculture and well trained in the art of irrigation, yet no one of the native peoples was tempted to settle upon this great strip of desert. For three hundred and fifty years after the Spanish invasion the Jornada lay in the beaten path of travel from Mexico northward. For 100 miles the famous El Paso and Santa Fe trail crossed its desert sands. In view of the horrors inspired by the trip across it from the time of Coronado to the advent of the railroad, the Spaniards who ventured within its borders might well be pardoned for calling it the "Journey of Death." The long white line of bleached bones of man and horse, which not so very long ago marked the trail, amply attested the fitness of the title.

Wallace[a] has described the Jornada in very somber though highly fanciful terms as follows:

> Near the southern boundary of New Mexico the Spanish explorers were opposed by a barrier of all on earth most to be dreaded—a shadeless, waterless plateau, nearly 100 miles long, from 5 to 30 miles wide, resembling the steppes of northern Asia. * * *
>
> The portion I speak of appears to have served its time, worn out, been dispeopled, and forgotten. The grass is low and mossy, with a perishing look—the shrubs, soapweed, and bony cactus writhing like some grisly skeleton; the very stones are like the scoria of a furnace. You vainly look for the flight of a bird, such as cheered the eyes of Thalaba in the desert; no bee nor fly hums in the empty air; and, save the lizard (the genius of desolation) and horn frog, there is no breath of living thing.
>
> Standing on the edge of the measureless waste, which is trackless as water, the first explorers might ask, "What is this strange ocean of sand, with its stillness more awful than any sea?"
>
> The spot I am trying to describe is the battle ground of the elements. In winter it is made fearful by raging storms of wind and snow. There men and animals have been frozen to death, their bodies left the lawful prey of the mountain wolf. From the primeval years the Apache has harried the hungry waste, hunting for scalps; and, besides the savagest of savages, it is now the favorite skulking place of outlaws, an asylum for fugitives escaping justice in old Mexico and Texas.
>
> In our times many a party cut off and many a traveler murdered makes good the name it bears, given by the first white men who dared its perils, Jornada del Muerto—"Journey of Death."

Repulsive as this picture is, it scarcely exaggerates the widespread impression which formerly existed concerning this country. Like much of the arid region, this district was considered waterless because no water appears on the surface. For three hundred and fifty years the traveler traversed this region without taking the trouble to dig beneath the surface of the plain for the moisture he so often longed for.

[a] Wallace, S. E., Land of the Pueblos, New York, 1888, p. 140.


LEGEND
Unknown
(or overlain by Quaternary)
Tertiary
(partly overlain by Quaternary)
Cretaceous
(mostly overlain by Quaternary)
Red beds
Carboniferous
(underlain by older sediments to the southeast)
Algonkian
(granite and schist)
Acid eruptive rocks
Basic eruptive rocks
Faults
MEXICO
Cutter
Aleman
Upham
Grama
Rincon
Hatch
Detroit
Sellers
SAN DIEGO MTN.
DONA ANA HILLS
ROBLERO MTN.
Dona Ana
Las Cruces
Tortugas
Mesilla
Bosque Seco
Mesquite
Telles
La Mesa
Earlham
Afton
Lenark
Organ
Principal Meridian
CERRO MAGDALENA
SOUTHERN PACIFIC RAILROAD
RIO GRANDE
LUNA
DONA
MUERTO
DEL
RANGE
33°
32°
107°

few signs of surface waters. As it is covered by loose, porous soils of unknown depth all the rainfall is quickly absorbed and the streams entering the plain from the mountains around the periphery soon sink below the surface.

In the long period that preceded the coming of the European the adjoining country was thickly populated by races highly skilled in agriculture and well trained in the art of irrigation, yet no one of the native peoples was tempted to settle upon this great strip of desert. For three hundred and fifty years after the Spanish invasion the Jornada lay in the beaten path of travel from Mexico northward. For 100 miles the famous El Paso and Santa Fe trail crossed its desert sands. In view of the horrors inspired by the trip across it from the time of Coronado to the advent of the railroad, the Spaniards who ventured within its borders might well be pardoned for calling it the "Journey of Death." The long white line of bleached bones of man and horse, which not so very long ago marked the trail, amply attested the fitness of the title.

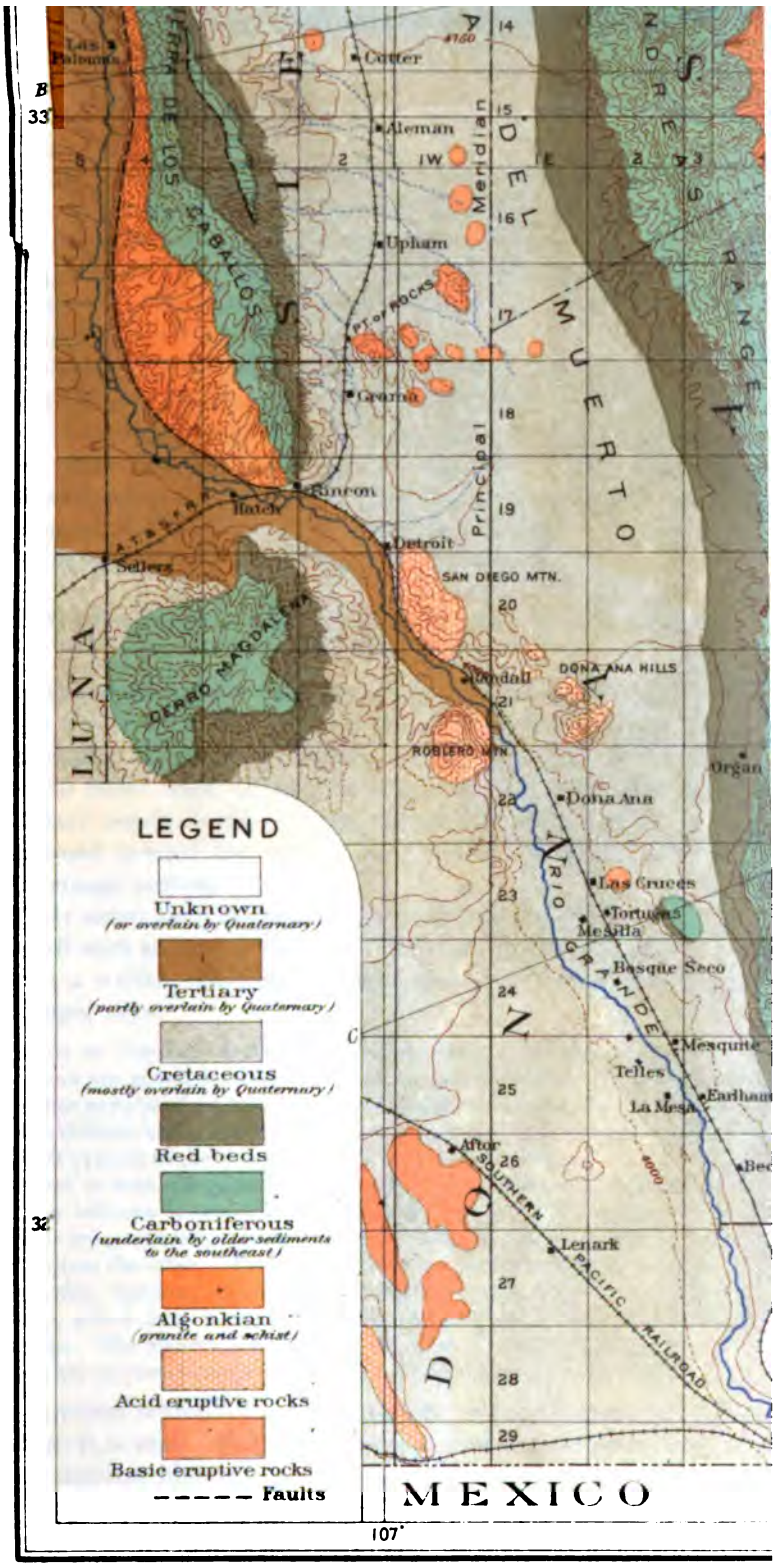
Wallace[a] has described the Jornada in very somber though highly fanciful terms as follows:

> Near the southern boundary of New Mexico the Spanish explorers were opposed by a barrier of all on earth most to be dreaded—a shadeless, waterless plateau, nearly 100 miles long, from 5 to 30 miles wide, resembling the steppes of northern Asia. * * *
>
> The portion I speak of appears to have served its time, worn out, been dispeopled, and forgotten. The grass is low and mossy, with a perishing look—the shrubs, soapweed, and bony cactus writhing like some grisly skeleton; the very stones are like the scoria of a furnace. You vainly look for the flight of a bird, such as cheered the eyes of Thalaba in the desert; no bee nor fly hums in the empty air; and, save the lizard (the genius of desolation) and horn frog, there is no breath of living thing.
>
> Standing on the edge of the measureless waste, which is trackless as water, the first explorers might ask, "What is this strange ocean of sand, with its stillness more awful than any sea?"
>
> The spot I am trying to describe is the battle ground of the elements. In winter it is made fearful by raging storms of wind and snow. There men and animals have been frozen to death, their bodies left the lawful prey of the mountain wolf. From the primeval years the Apache has harried the hungry waste, hunting for scalps; and, besides the savagest of savages, it is now the favorite skulking place of outlaws, an asylum for fugitives escaping justice in old Mexico and Texas.
>
> In our times many a party cut off and many a traveler murdered makes good the name it bears, given by the first white men who dared its perils, Jornada del Muerto—"Journey of Death."

Repulsive as this picture is, it scarcely exaggerates the widespread impression which formerly existed concerning this country. Like much of the arid region, this district was considered waterless because no water appears on the surface. For three hundred and fifty years the traveler traversed this region without taking the trouble to dig beneath the surface of the plain for the moisture he so often longed for.

---

[a] Wallace, S. E., Land of the Pueblos, New York, 1888, p. 140.


LEGEND
Unknown
(or overlain by Quaternary)
Tertiary
(partly overlain by Quaternary)
Cretaceous
(mostly overlain by Quaternary)
Red beds
Carboniferous
(underlain by older sediments to the southeast)
Algonkian
(granite and schist)
Acid eruptive rocks
Basic eruptive rocks
Faults
MEXICO
Las Palomas
Cutter
Aleman
Upham
Grama
Rincon
Hatch
Detroit
Sellers
SAN DIEGO MTN.
DONA ANA HILLS
ROBLERO MTN.
Dona Ana
Las Cruces
Tortugas
Mesilla
Bosque Seco
Mesquite
Telles
La Mesa
Earlham
Afton
Lenark
Organ
Principal Meridian
SOUTHERN PACIFIC RAILROAD
RIO GRANDE
CERRO MAGDALENA
LUNA
DONA
MUERTO
DEL
ANDREAS RANGE
33°
32°
107°

few signs of surface waters. As it is covered by loose, porous soils of unknown depth all the rainfall is quickly absorbed and the streams entering the plain from the mountains around the periphery soon sink below the surface.

In the long period that preceded the coming of the European the adjoining country was thickly populated by races highly skilled in agriculture and well trained in the art of irrigation, yet no one of the native peoples was tempted to settle upon this great strip of desert. For three hundred and fifty years after the Spanish invasion the Jornada lay in the beaten path of travel from Mexico northward. For 100 miles the famous El Paso and Santa Fe trail crossed its desert sands. In view of the horrors inspired by the trip across it from the time of Coronado to the advent of the railroad, the Spaniards who ventured within its borders might well be pardoned for calling it the "Journey of Death." The long white line of bleached bones of man and horse, which not so very long ago marked the trail, amply attested the fitness of the title.

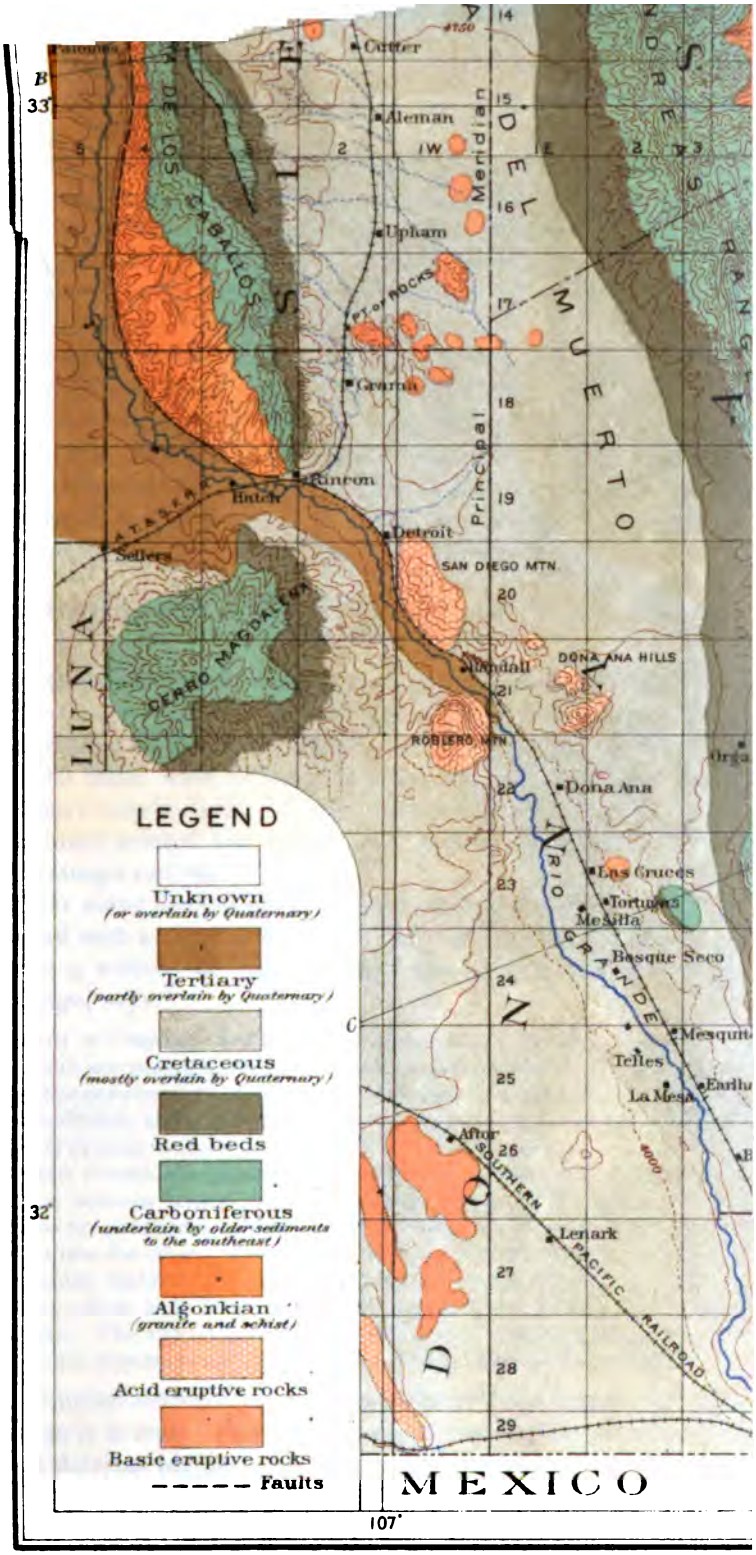
Wallace[a] has described the Jornada in very somber though highly fanciful terms as follows:

> Near the southern boundary of New Mexico the Spanish explorers were opposed by a barrier of all on earth most to be dreaded—a shadeless, waterless plateau, nearly 100 miles long, from 5 to 30 miles wide, resembling the steppes of northern Asia. * * *
>
> The portion I speak of appears to have served its time, worn out, been dispeopled, and forgotten. The grass is low and mossy, with a perishing look—the shrubs, soapweed, and bony cactus writhing like some grisly skeleton; the very stones are like the scoria of a furnace. You vainly look for the flight of a bird, such as cheered the eyes of Thalaba in the desert; no bee nor fly hums in the empty air; and, save the lizard (the genius of desolation) and horn frog, there is no breath of living thing.
>
> Standing on the edge of the measureless waste, which is trackless as water, the first explorers might ask, "What is this strange ocean of sand, with its stillness more awful than any sea?"
>
> The spot I am trying to describe is the battle ground of the elements. In winter it is made fearful by raging storms of wind and snow. There men and animals have been frozen to death, their bodies left the lawful prey of the mountain wolf. From the primeval years the Apache has harried the hungry waste, hunting for scalps; and, besides the savagest of savages, it is now the favorite skulking place of outlaws, an asylum for fugitives escaping justice in old Mexico and Texas.
>
> In our times many a party cut off and many a traveler murdered makes good the name it bears, given by the first white men who dared its perils, Jornada del Muerto—"Journey of Death."

Repulsive as this picture is, it scarcely exaggerates the widespread impression which formerly existed concerning this country. Like much of the arid region, this district was considered waterless because no water appears on the surface. For three hundred and fifty years the traveler traversed this region without taking the trouble to dig beneath the surface of the plain for the moisture he so often longed for.

---

[a] Wallace, S. E., Land of the Pueblos, New York, 1888, p. 140.


LEGEND
Unknown
(or overlain by Quaternary)
Tertiary
(partly overlain by Quaternary)
Cretaceous
(mostly overlain by Quaternary)
Red beds
Carboniferous
(underlain by older sediments to the southeast)
Algonkian
(granite and schist)
Acid eruptive rocks
Basic eruptive rocks
Faults
MEXICO
Cutter
Aleman
Upham
Grama
Rincon
Hatch
Detroit
Sellers
SAN DIEGO MTN.
DONA ANA HILLS
ROBLERO MTN.
Dona Ana
Las Cruces
Tortugas
Mesilla
Basque Seco
Mesquite
Telles
La Mesa
Earlha
Aftor
Lenark
SOUTHERN PACIFIC RAILROAD
RIO GRANDE
Principal Meridian
CERRO MAGDALENA
LUNA
DEL MUERTO
33°
32°
107°

few signs of surface waters. As it is covered by loose, porous soils of unknown depth all the rainfall is quickly absorbed and the streams entering the plain from the mountains around the periphery soon sink below the surface.

In the long period that preceded the coming of the European the adjoining country was thickly populated by races highly skilled in agriculture and well trained in the art of irrigation, yet no one of the native peoples was tempted to settle upon this great strip of desert. For three hundred and fifty years after the Spanish invasion the Jornada lay in the beaten path of travel from Mexico northward. For 100 miles the famous El Paso and Santa Fe trail crossed its desert sands. In view of the horrors inspired by the trip across it from the time of Coronado to the advent of the railroad, the Spaniards who ventured within its borders might well be pardoned for calling it the "Journey of Death." The long white line of bleached bones of man and horse, which not so very long ago marked the trail, amply attested the fitness of the title.

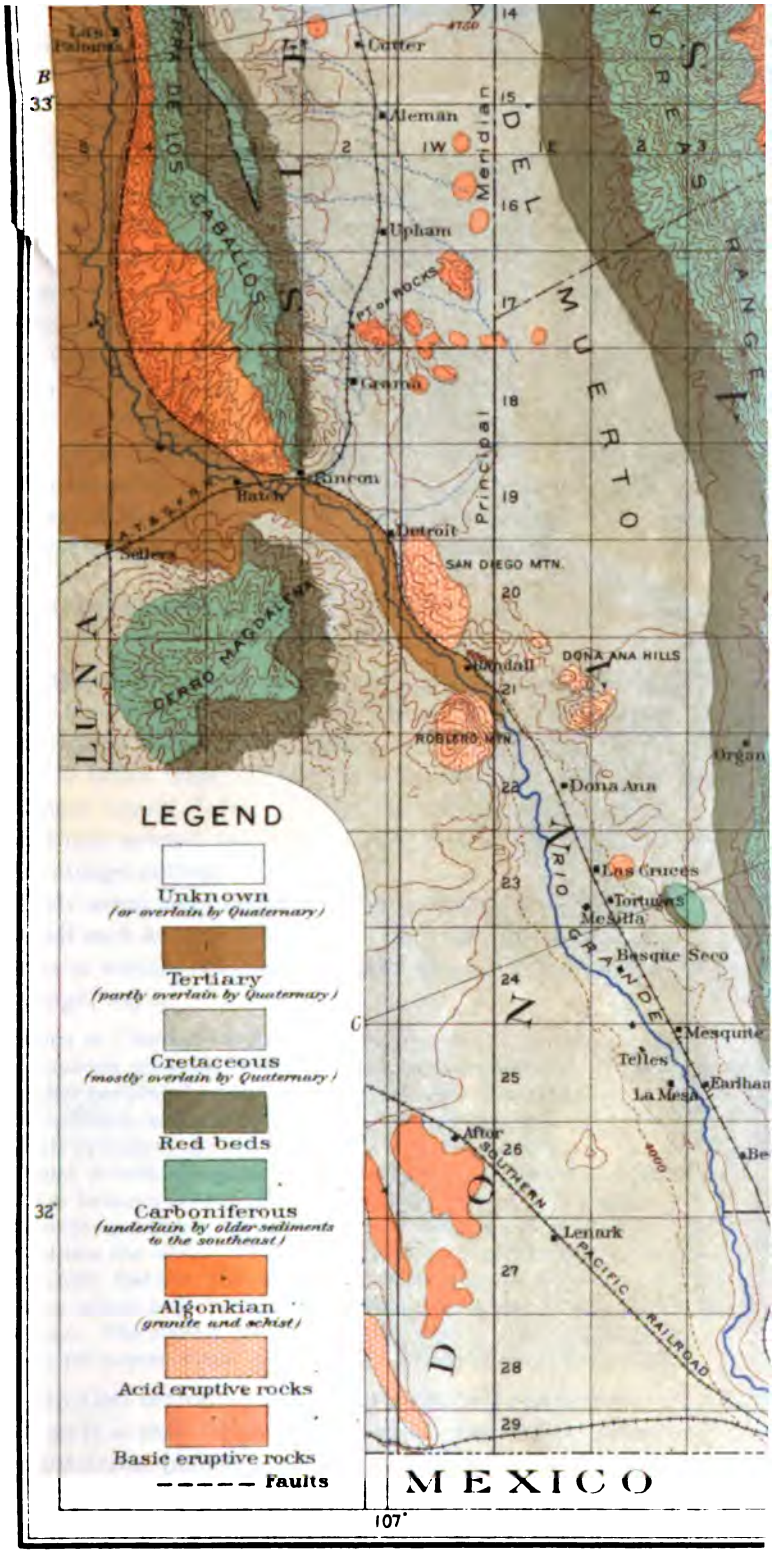
Wallace[a] has described the Jornada in very somber though highly fanciful terms as follows:

> Near the southern boundary of New Mexico the Spanish explorers were opposed by a barrier of all on earth most to be dreaded—a shadeless, waterless plateau, nearly 100 miles long, from 5 to 30 miles wide, resembling the steppes of northern Asia. * * *
>
> The portion I speak of appears to have served its time, worn out, been dispeopled, and forgotten. The grass is low and mossy, with a perishing look—the shrubs, soapweed, and bony cactus writhing like some grisly skeleton; the very stones are like the scoria of a furnace. You vainly look for the flight of a bird, such as cheered the eyes of Thalaba in the desert; no bee nor fly hums in the empty air; and, save the lizard (the genius of desolation) and horn frog, there is no breath of living thing.
>
> Standing on the edge of the measureless waste, which is trackless as water, the first explorers might ask, "What is this strange ocean of sand, with its stillness more awful than any sea?"
>
> The spot I am trying to describe is the battle ground of the elements. In winter it is made fearful by raging storms of wind and snow. There men and animals have been frozen to death, their bodies left the lawful prey of the mountain wolf. From the primeval years the Apache has harried the hungry waste, hunting for scalps; and, besides the savagest of savages, it is now the favorite skulking place of outlaws, an asylum for fugitives escaping justice in old Mexico and Texas.
>
> In our times many a party cut off and many a traveler murdered makes good the name it bears, given by the first white men who dared its perils, Jornada del Muerto—"Journey of Death."

Repulsive as this picture is, it scarcely exaggerates the widespread impression which formerly existed concerning this country. Like much of the arid region, this district was considered waterless because no water appears on the surface. For three hundred and fifty years the traveler traversed this region without taking the trouble to dig beneath the surface of the plain for the moisture he so often longed for.

---

[a] Wallace, S. E., Land of the Pueblos, New York, 1888, p. 140.


LEGEND
Unknown
(or overlain by Quaternary)
Tertiary
(partly overlain by Quaternary)
Cretaceous
(mostly overlain by Quaternary)
Red beds
Carboniferous
(underlain by older sediments to the southeast)
Algonkian
(granite and schist)
Acid eruptive rocks
Basic eruptive rocks
Faults
MEXICO
107°
32°
33°
Las Palomas
Cutter
Aleman
Upham
Grama
Rincon
Hatch
Detroit
Sellers
Randall
Dona Ana
Las Cruces
Tortugas
Mesilla
Bosque Seco
Mesquite
Telles
La Mesa
Earlham
Afton
Lenark
Organ
Meridian
Principal
SAN DIEGO MTN.
DONA ANA HILLS
ROBLERO MTN.
RIO GRANDE
SOUTHERN PACIFIC RAILROAD
CERRO MAGDALENA
CABALLOS
DEL MUERTO
DONA
LUNA
RANGE

Apparently it was not suspected that, owing to certain local peculiarities in the geologic formations, abundant water lay at comparatively shallow depths. In 1871 a well 160 feet deep was dug in the middle of the plain by a ranchero, John Martin, and cool, soft water was obtained in great quantity, so that his ranch became the resting place of every traveler crossing the desert.

The geologic conditions in New Mexico are less known than in any other region of equal size in the United States. With the exception of a few comparatively limited areas studied by the Federal surveys, but little detailed investigation has been undertaken. The geologists connected with the early Government surveys have given a general idea of the geologic formations, but the exact age and relations of most of the rocks remain to be determined.

GENERAL CHARACTER OF THE NEW MEXICAN PLATEAU REGION.

Among the most notable features of central and southwestern New Mexico are the broad desert plains, out of which the mountain ridges rise as abruptly as volcanic islands out of the sea. These plains are 20 to 30 miles wide, often 100 miles or more long, and at first glance appear nearly level. Closer inspection shows that they are basins inclined toward the center and devoid of marked drainage ways or drainage outlets.

With their usual keen distinctions of geographic features, the Spanish aptly call such an inclosed plain a "bolsone," meaning a purse. Of these plains a writer, who has brought their Spanish name into geographic usage, says:

> These plains or "basins," as they are sometimes called, are largely structural in origin. Bolsons are generally floored with loose unconsolidated sediments derived from the higher peripheral region. Along the margin of these plains are talus hills and fans of bowlders, and other wash deposits brought down by mountain freshets. The sediments of some of the bolsons may be of lacustral origin.
>
> It is essential in both the geographic and the geologic discussion to bear in mind the distinction between bolson plains and plateau plains. The plateau plains and the mountains are genetically related, the strata composing the one being bent on to or flexing out into the other. The bolson plains, on the other hand, are newer and later topographic features consisting of structural valleys between mountains or plateau plains, which have been partially filled with débris derived from the adjacent eminences. The plateau plains are usually destructional stratum plains. The bolson plains are constructional detritus plains filling old structural troughs. [a]

The distinction between the plateau plains and the bolson plains is as important as it is real. But the statement that bolson plains are constructional detritus plains in structural valleys does not convey a correct idea of the phenomenon, and, as generally understood, the term structural, as applied to these valleys, is very apt to be misinterpreted.

[a] Hill, R. T., Topographic Atlas U. S., folio 3, U. S. Geol. Survey, 1900, p. 8.

In a carefully qualified sense the valleys occupied by the bolson plains might, perhaps, be considered structural valleys, but their history is very much more complex and very different from what might be suspected from casual observation.

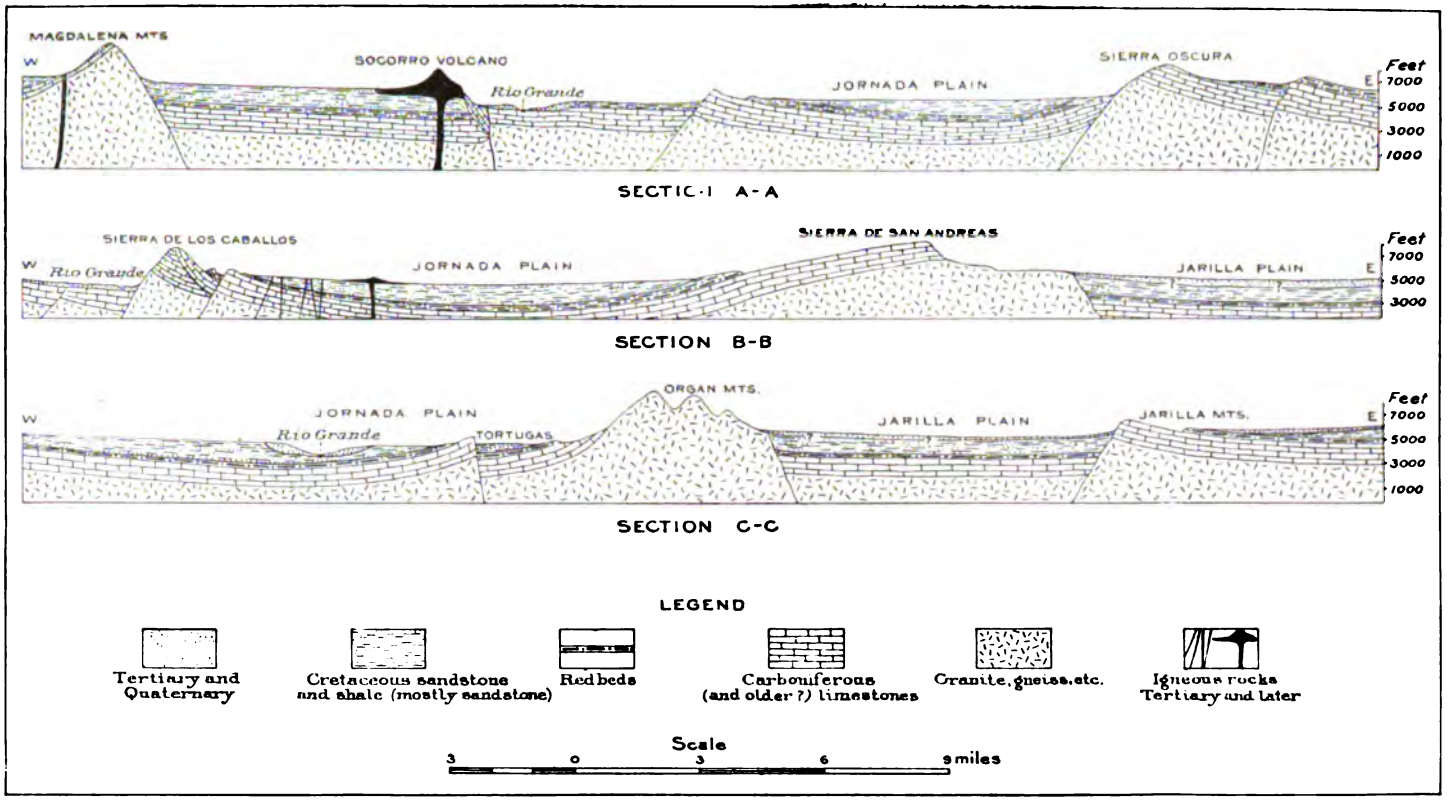
The alternation in central New Mexico of narrow mountain ridges and broad plains, of which the Jornada is a characteristic example, presents some features which are not easily understood until the regions both to the east and to the west are taken into consideration. In both directions the basin character of the bolson plains is soon lost. The plains become confluent and more continuous, and the mountain ranges more disconnected and finally isolated altogether. Farther on the plain alone persists without notable mountains. This condition continues on the one hand to the Gulf of California and on the other to the Gulf of Mexico.

At the beginning of Tertiary time the region between the two great gulfs south of what is now the Colorado line must have been a vast lowland plain with but faint relief features. A large part of this plain was on the beveled edges of Cretaceous and older strata, as is shown now in its remnants still clearly discernible. The Las Vegas Plateau, the Llano Estacado, the bolson plains of central New Mexico, and some of the less broken plains of eastern Arizona seem to belong genetically together. To the east and the west a broad submarine platform was formed from the sediments derived from the planing off of the central land area. When the general uplift of the region took place later in the Tertiary the great plain formed was partly a peneplain of destructional land origin and partly a constructional plain of marine origin.

In the uprising, however, faulting took place on a large scale, giving rise to the numerous monoclinal block mountains in the region now within the boundaries of New Mexico. There were various halts in the general uplift, and the Mesozoic and youngest Paleozoic beds were stripped off the mountain summits. Two or three times during halts in the uplift partial planation took place. With the progression of the uplift the mountain blocks finally became more and more tilted.

Between Tertiary and present time an enormous amount of erosion has taken place. The vast plain has been deeply dissected by the Canadian, Pecos, Rio Grande, and Colorado rivers—old, mountain-born streams. The valleys of these water courses are very wide and deep. On the east the Canadian flows 4,000 feet below the level of the old plain, the Pecos perhaps 2,500 feet, the Rio Grande about 1,500 feet, while the Colorado Canyon is a mile deep.

In the Llano Estacado the remnant of the great high plain has an area of 50,000 square miles. The bolsons are already beginning to give way to erosion agencies. In the valley of the Rio Grande nearly



CROSS SECTION OF THE REGION, ALONG LINES A-A, B-B, AND C-C, PL. I.

all traces of one old plain are already destroyed. The displaced intermontane basins like the Jornada, which adjoin the long Rio Grande Valley, are being deeply dissected wherever the great river touches the borders.

SURFACE RELIEF OF THE JORNADA.

GENERAL FEATURES.

The Jornada basin is roughly pear-shaped in outline, with the stem end at El Paso (see geologic sketch map, Pl. I). From this point the basin plain extends northward into central New Mexico, a distance of 200 miles. In width the plain expands to 30 or 40 miles.

Of late years only the central part of the basin has been called the Jornada del Muerto. As a physiographic feature the plain is unbroken from the Mesa Jumanes and the Cerro Montosa, which cuts it off to the north from the great Estancia bolson, to the canyon of the Rio Grande at El Paso. The Mesilla Valley is not a separate basin, as often reported, but a portion traversed by the Rio Grande, which enters the lower part of the plain.

In the central part the Jornada is a flat-bottomed basin, with borders turned abruptly upward on all sides like a miner's pan. Forming the rim are long, narrow mountain ranges which rise to heights of 2,000 to 3,000 feet above the plain. The floor of the basin slopes to the south. At the north end the altitude is about 6,300 feet, while at the southern extremity it is 3,800 feet. There is a descent of 2,500 feet in 200 miles, a rate of about 12 feet to the mile.

West of the Jornada, running its entire length, is the Rio Grande del Norte, which flows in a basin of its own. While at the north end the elevation of the Jornada is 1,600 feet above the river, at the southern limit where the stream cuts across the rim the height above the great water course is only about 100 feet. The river falls 1,000 feet in a distance of 200 miles; the fall of the plain in the same distance is 2,500 feet or more.

Viewed from the railroad the plain appears even and level, the only features breaking the smoothness of its general surface being isolated and irregular volcanic cones which follow down the middle of the basin for its entire length. These, however, are recent outflows on the surface of the plain and genetically do not interrupt its continuity.

Where the Rio Grande touches the Jornada, and where it traverses its southern part, the plain is deeply dissected. At the foot of the mountains the smooth floor of the basin passes into slopes deeply incised by arroyos.

In the main the rocks of the Jornada basin form a synclinal trough (Pl. II), but the dip of the beds is considerably greater than the slope of the land toward the center of the valley. As a result the beds are beveled, and toward the mountains on either side a thick

series of rocks is exposed wherever the surface gravels are removed. The basin is a destructional plain deeply covered by recent gravels and coarse deposits, with probably some lake sediments of limited extent.

Physiographically the bolson is very young. Erosion has as yet cut but little into the plain. The original constructional form of the present topographic cycle is everywhere in evidence. Only where the Rio Grande touches the borders of the plain have even the soft beds begun to wear out into lowlands.

Of the drainage little need be said. In general all waters flow toward the center of the plain and there are are no cross drainage ways. The numerous watercourses coming down from the mountains are quickly imbibed by the porous deposits and become "lost rivers." This is true also of the few small perennial streams as well as of the torrents which rush down the arroyos carrying only the storm waters.

On the west side of the basin the waters from the mountains do not drain out into the plains, but quickly disappear down deep canyons which debouch into the Rio Grande through gaps in the ranges.

In the central part of the basin are numerous shallow depressions into which the storm waters gather and form lakes of considerable size. Some of these retain their waters for several months and frequently through the year.

CENTRAL FLOOR OF THE BASIN.

As already stated, the Jornada presents the appearance of an almost level plain (Pl. III, *A*), slightly depressed in the middle. Closer inpection shows that the apparent smoothness is locally broken in various ways. The appearance of general evenness is due partly to optical illusion on account of the vastness of the field.

Low conical hills of volcanic origin rise above the plain at various points throughout its entire length. Most of these are unnamed, but some of the larger ones, especially in the southern part of the basin, have received specific designations. Dona Ana Hills, San Diego Mountains, and Cerro Robtero may be mentioned.

All of these volcanic cones are very recent, and some of them still have their craters perfectly preserved. Extensive basalt flows extend from some of the cones, one of which, located south of San Marcial, covers more than 100 square miles. Several remarkably symmetrical cones occur west of Engle station, near old Fort McRae. These are about 200 feet in height, while the Dona Ana Hills, for example, are more than four times this elevation.

EASTERN RIM OF THE BASIN.

On the east side of the Jornada basin is a ridge which rises abruptly to a height of 3,000 feet above the plain. While there are a number of low passes through the ridge, no one of these is low enough to serve as a drainage outlet to the basin.

A. VIEW OF NORTHERN END OF THE JORNADA.

B. THE WHITE CLIFFS AT LOWER END OF ORGAN MOUNTAINS.

Shows Carboniferous limestone dipping west.

Through great faulting on the eastern side of the ridge the various mountain blocks have been tilted up so that the long back slopes form a part of the broad syncline of the region to the west.

Beginning at the south these blocks have received the name of Franklin Mountains, Organ Mountains, San Andreas Range, Oscura Range, and Chupadera Mesa. The last two ranges mentioned slope to the east instead of the west, the main fault passing between the Oscura and San Andreas sierras. Here two lofty fault scarps face each other, separated only by a comparatively narrow valley.

The characteristic aspect of the Franklin Range and the southern Organ Mountains is well shown by Peña Blanca (Pl. III, *B*). The main mass is composed of Carboniferous limestone and rises nearly 1,000 feet above the plain at the foot. The rugged character of the Organ Mountains is well displayed by the contour map of the region.

The great fault scarp of the Sierra Oscura is a mountain block rising about 3,000 feet above the plain. In the lower three-fourths the granites and schists occur, and the long back slope is a heavy plate of blue Carboniferous limestone nearly 1,000 feet thick. Farther northward the eastern rim of the Jornada is formed by the Chupadera Mesa, which rises in an abruptly westward-facing escarpment several hundred feet high. The view of the escarpment shown in Pl. IV, *A*, is from the plain at a distance of 2 miles. The face of the escarpment is composed of Cretaceous sandstones, but a short distance back from the crest the surface of the mesa is made up of Carboniferous limestones. The sharp hill in the left foreground is a huge trachyte dike which extends away from the observer across the mesa a distance of 12 miles or more.

With the exception of the extreme northern portion the entire runoff of the eastern rim flows down the limestone incline to the foot of the ranges, then over red shales into the sandstone area forming the floor of the basin.

Since near the eastern ridge there is no large watercourse such as the Rio Grande, which flows along the western rim, the surface at the foot of the mountains presents but little of the relief that occurs on the western border of the plain.

WESTERN RIM OF THE BASIN.

Like the eastern side of the Jornada, the western side consists of high ridges trending north and south and dipping toward the basin. Geologically the western rim is similar to the eastern and of about the same height. There is, however, this difference: The western portion is broken at several places and the Rio Grande has begun to make inroads into the plain. Toward the south that stream crosses a part of the plain, forming the Mesilla Valley.

The mountains forming the western boundary of the plain consist at the south of a number of rather low, unnamed ridges, lying on the

western side of the Rio Grande. The Cerro Magdalena, southwest of Rincon, appears to be the most important of the ridges which lie west of the river. The Sierra de los Caballos and Sierra Fra Cristobal are large ranges, comparable to those on the east side of the plain. Continuing northward is a long line of mountains from 8 to 10 miles east of the Rio Grande, which extend almost unbrokenly for a distance of 50 miles to the Cerro Montosa. All of these mountains have a conspicuous fault scarp marking their western flank.

At the north end of the Sierra Fra Cristobal, where for a short distance the Rio Grande breaks the rim of the Jornada, erosion is beginning to cut into the plain and considerable indentation has been already made. By headwater erosion the small drainage ways (dry except in time of heavy rains, which happen only a few times each year) are rapidly cutting into the border. The local drainage for a distance of nearly a quarter of the way across the plain is now turned in this direction, and when the driving rains come powerful corrasion takes place along these arroyos. The Rio Grande is 800 to 1,000 feet below the plain, and the gradient of the arroyos is over 100 feet to the mile.

Other important gaps permitting the drainage waters of the plain to enter the Rio Grande are at the northern and the southern ends of the Caballos Range, and in the center at Palomas Canyon. The run-off of the Jornada side of this entire range is allowed to enter the Rio Grande instead of flowing out onto the plain and there sinking beneath the surface. A strip of country 4 miles wide on the average and 20 miles long thus drains into the Rio Grande. This belt is faulted in many places. It is traversed by basic dikes and is altogether a rough country. The difference in elevation of near-by points is often as much as 300 feet. The canyons are numerous and labyrinthine, with high gradients. Mescal Canyon and Palomas Canyon are the two master drainage ways, into which all others empty before their waters cross the mountain axis and fall into the Rio Grande.

The tops of the hills in this rough strip are nearly all on a level, which is the same as that of the plain projected westward. Consequently, when viewed from the railroad train, at a distance of about 12 miles, the plain appears unbroken to the very foot of the mountains.

In some places, as at the north end of the Sierra de los Caballos, are extensive lava beds which were poured out on the surface of the plain. Mescal Canyon cuts through one of these sheets, displaying fine sections of the beveled Cretaceous sandstones and the overlying gravels which once constituted the floor of the plain and which now form the floor beyond the limits of the lava flows. The bottom of the lava sheet is on a level with the tops of the hills of the neighborhood, also showing conclusively that at the present time erosion has progressed sufficiently to intricately and deeply dissect the country, but not far enough to destroy the last remnants of the Jornada's sur-

A. ESCARPMENT OF THE CHUPADERA MESA.

B. PEÑASCO ROCK.

face lying in this belt. North of this Mescal Canyon lava sheet is another similar one, a detached mass, known as Elephant Butte, near which is a reservoir site which, owing to prolonged litigation, has become one of the best known in the country.

At the south end of the Sierra de los Caballos the Rio Grande enters the Jornada and cuts a deep trench diagonally across this plain to the south end of the Franklin Range at El Paso. The distance is 65 miles. In passing through the central part of the plain the stream encounters several groups of volcanic mountains, which are known as the San Diego Mountains, the Dona Ana Hills, Cerro Roblero, etc. This part of the river's course is a rather narrow canyon, the sides of which exhibit many benches at various elevations above the present level, showing that the lava flows acted as temporary dams. In this part of its course the real nature and relationships to the great bolson of the country adjacent to the river are so disguised that many of its features are apt to be misinterpreted.

At Mesilla the valley of the Rio Grande broadens out into a wide flood plain, known as the Mesilla basin. The Atchison, Topeka and Santa Fe Railroad follows the banks of the Rio Grande for the entire distance from Rincon, where it comes down from the upland plain, to El Paso. From Rincon southward the western rim of the Jornada, while still high, is not so sharply marked as farther northward.

NORTHERN RIM OF THE BASIN.

At the north end of the Jornada the rim of the basin does not present the high mountainous aspects of the sides. There is, however, a broadly curved line of hills marking the boundary (Pl. III, *A*). These are 500 to 800 feet high, and are produced by upturned strata. This chain of hills is broken through at a number of points by deep arroyos, whose storm waters are soon lost in the plain.

At one place, near the west side, a broad, flat-bottomed valley several miles in width opens out to the northward. It extends in that direction many miles and appears to be continuous with the floor of the Estancia bolson farther north. The deeply dissected Chupadera Mesa forms the northeastern wall of the basin.

Beyond the rim a considerable area is drained into the basin through arroyos. The principal one of these watercourses is located near the center of the north wall, and is known as the Arroyo Chupadera. At the point where it cuts the rim, in a deep canyon, is located the Ojo Chupadera.

SOUTHERN SIDE OF THE BASIN.

The southern side of the upland Jornada plain is a mountainous belt of country extending in long finger-like projections across the national boundary from Mexico. These are the northern ends of several Mexi-

can ranges, the principal one of which is the Sierra de los Muleros. At El Paso the Rio Grande has carved its way through the hard mountain rock, forming a narrow canyon only wide enough to permit the passage of the river. At this point the east ridge is the southern extremity of the Franklin Range, which here represents the eastern rim of the basin. The high mountain to the west of the river is said to be marked by benches to a height of 800 feet above the river level.

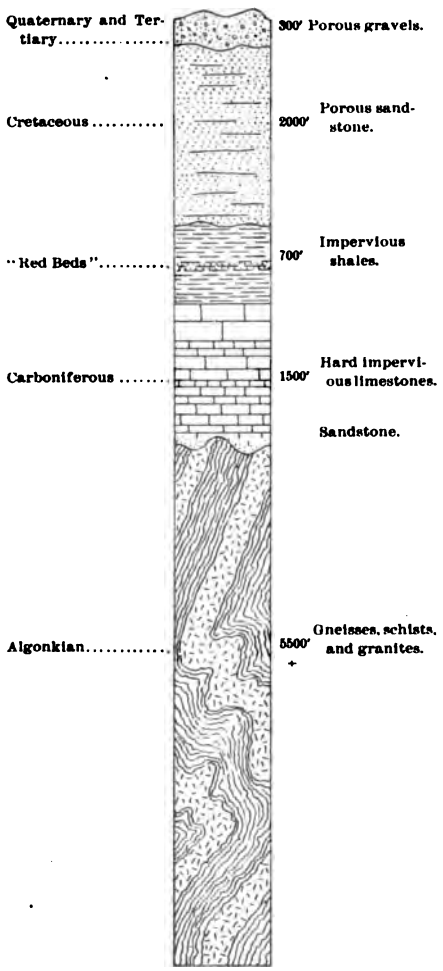


FIG. 2.—Geologic column.

West of the Rio Grande the normal character of the great plain is greatly obscured by late protrusions of volcanic materials. Conspicuous cones rise out of the plain at many points, and extensive lava sheets cover the surface.

THE FORMATIONS.

GENERAL GEOLOGIC RELATIONS.

The geologic formations of south-central New Mexico comprise five very marked classes of rocks (see fig. 2). At the base is a great mass of crystalline rocks, chiefly granites, gneisses, and schists, with some metamorphic rocks which can not always be directly distinguished from the members of the fundamental complex. These crystalline rocks are, in greater part at least, Archean and Algonkian in age. The later Paleozoic rocks are widely distributed, and are mainly thick blue limestones, mostly of Carboniferous age, which form chiefly the crests and back slopes of many of the principal mountain ranges. A third class of rocks is found in the thick and extensive beds of massive yellow sandstones of Cretaceous age. Over all these indurated rocks lies a mantle of soft clays, sands, and gravels, largely deposited during the late Tertiary and Quaternary periods. Later than all of these are outflows of igneous rock which also cover many thousands of square

A. ELEPHANT BUTTE.

View taken from big bend in Rio Grande.

B. SOLEDAD CANYON, A MOUNTAIN ARROYO.

miles within the limits of New Mexico. The period during which these volcanic rocks were erupted extends from the early Tertiary down probably to within the time of the settlement of America by Europeans.

The stratigraphic relations of the several rock masses are represented in fig. 2. As will be noted, marked unconformities separate the different formations, the single exception being between the "Red Beds" and the Carboniferous. The geologic significance of these unconformities is of exceptional interest.

The thicknesses given are in all cases maximum measurements. The great thickness of the Tertiary gravels and the Cretaceous sandstones is found only in the middle part of the Jornada, and from this middle line there is a rapid diminution toward the eastern and western rims of the basin.

ARCHEAN SYSTEM.

In recent years geologic opinion regarding the crystalline rocks which underlie the great sedimentary succession in the New Mexico area has undergone some very radical changes, most of the extensive formations composed of granites, schists, gneisses, and slates, which form the core of many of the mountain ranges, being now classified in a later geologic age than the Archean.

It is thought that true Archean rocks are exposed only in the southern extremity of the Sangre de Cristo ranges within the boundaries of New Mexico. Possibly also some of the basement crystallines of the Mogollon and Burro mountains in western New Mexico and of the Sierra de los Caballos on the western rim of the Jornada may finally prove to be of Archean age. Even in these localities the areas which may be properly referred to the Archean are of limited extent.

ALGONKIAN SYSTEM.

Most of the mountain ranges of central New Mexico are huge tilted blocks, one side being a long slope and the other a steep face, originally a fault scarp. In the steep face a considerable portion of the basal part is often found to be made up of quartzites, micaceous and hornblendic schists, gneisses, and granites. The foliation of these highly metamorphosed rocks is usually nearly vertical. Where they are overlain by the basal quartzites and limestones above they are sharply beveled off, and the stratification of the sedimentary beds is nearly at right angles to the planes of lamination beneath.

For a long time it was thought that this crystalline complex represented the Archean. Late investigation has shown conclusively that many so-called "quartz veins" are in reality quartzites, and in thin section under the microscope this rock is seen to be of sedimentary character. Many of the dark-colored schists were without doubt originally basic intrusives, and some of the gneisses were granites

now profoundly sheared. These masses are frequently seen to be penetrated by later acid eruptives now forming vast irregular bodies and sheets of red granite, some of which probably are later than Algonkian.

These highly metamorphosed masses are referred to the Algonkian age. They are more or less mineralized in the various mountain systems, containing many of the extensive deposits of copper, iron, silver, gold, and some of the rarer metals. These rocks are well displayed in all of the ranges surrounding the Jornada plain.

The Algonkian rocks of the Grand Canyon section have not been recognized in New Mexico, and if they are represented it is not with the same characteristics and succession. It is possible, however, that more detailed study of the New Mexico field will disclose relationship to the Grand Canyon section. The main succession there is as follows: (1) Vishnu quartzite at the base, (2) Grand Canyon sandstone with interbedded and cutting basic eruptives, and (3) Chuar shales and limestones.

ROCKS OF EARLY PALEOZOIC AGE.

At present there is no reliable evidence that any of the lower Paleozoic beds are represented within the limits of the region under consideration. The great Cambrian, Ordovician, Silurian, and Devonian systems which are so extensively developed in other parts of the American continent have thus far not been observed in central New Mexico.

The Cambrian deposits, known elsewhere as the Tonto formation, and so well developed in the Grand Canyon district, may be represented in western New Mexico in some of the massive indurated sandstones. In central New Mexico, in the Sandia, Caballos, and San Andreas ranges, there is a massive quartzite 50 to 100 feet in thickness, the lower part of which is a conglomerate, but it is conformable with the overlying Carboniferous limestones. The quartzite member reposes upon the upturned edges of the Algonkian formations, indicating clearly that an enormous erosion interval separated the two. It would not be surprising if this erosion plane represents all except the latest Paleozoic sedimentation in other parts of the country. In some of the New Mexico mountain ranges this quartzite carries important copper deposits.

It was once believed that the formations subjacent to the great Carboniferous limestone were the metamorphosed beds of the lower Paleozoic; but this hypothesis does not now seem to have foundation.

CARBONIFEROUS SYSTEM.

The rocks of the Carboniferous system appear to be the only part of the great Paleozoic sequence that are represented in central New Mex-

A ORGAN MOUNTAINS, NEW MEXICO, SHOWING BREAK OFF OR CHANGE IN TOPOGRAPHY.

B. VIEW SHOWING LOCATION OF CANAL LINE RUNNING ALONG SMALL RIDGES DIRECTLY BACK OF AGRICULTURAL COLLEGE.

ico. With the standard Carboniferous section for the American continent, as represented in the Mississippi Valley, the New Mexico sections do not as yet admit of detailed comparison.

The Carboniferous rocks of New Mexico are very important formations. They are found in most of the principal mountain ranges and in most localities they are important ore carriers. As guide horizons they deserve the fullest consideration in the location of all mineral deposits.

Four important formations belonging to the Carboniferous system have been clearly made out in the district under consideration. They are the lower Carboniferous, the middle Carboniferous, the upper Carboniferous, and the so-called Permo-Carboniferous. The three series of Coal Measures of the middle Carboniferous so enormously developed in the Mississippi Valley have not been differentiated in the West. They are, however, doubtless represented entirely by limestones.

The lowest series of the Carboniferous has been recognized in a number of localities. Among these places is one just outside of the area here mapped, in the vicinity of Lake Valley, which deserves special mention. Here has been found an extensive limestone series carrying a rich fauna identical with that of the lower Burlington limestone in Missouri, Iowa, and Illinois. Professor Herrick has also reported a similar lower Carboniferous from the east side of the San Andreas Range.

The great limestone sheets which cap the principal mountain ranges in south-central New Mexico, and which form their back slopes, are of upper and middle Carboniferous age. Immediately beneath these limestones is usually found a white quartzite which often passes downward into a coarse conglomerate. The quartzite with its coarse beds rests unconformably on the upturned edges of a metamorphic series, as already stated.

The great limestones are easily distinguished from all others of the region by their black and blue to gray colors, their peculiar compact texture, and the abundant characteristic fossils which they contain. The thickness of the formation is from 300 to probably more than 1,000 feet. They are everywhere massively bedded and some localities contain thick beds of very pure white limestone. In most of the principal mining districts the Carboniferous limestone carries important lead and silver deposits. The quartzite frequently carries copper.

In the Sandia Mountains, to the north of the district here described, several subordinate formations have been differentiated. The basal conglomerate and associated sandstones have been called the Sandia quartzite. The next member is a black limestone. According to the best available evidence derived from the contained fossils these beds correspond to the earlier Pennsylvanian of the Mississippi Valley.

The upper part of the great limestone formation—the blue to gray beds—contains an abundant fauna that clearly points to late Pennsylvanian age. In the Sandia Mountains this formation is called the "Madera" limestone. It forms by far the most important portion of the Carboniferous in all of the mountain ranges mentioned.

Above the great blue limestones of the Carboniferous there is an important sandstone, and then a sequence of shales and sandstones conspicuous for their remarkable red coloration. "Red Beds," they are generally called. These "Red Beds" are followed by other red beds scarcely distinguishable lithologically. The latter are believed to belong not to the Carboniferous, but to the Jurassic-Triassic.

The so-called Permo-Carboniferous red beds are found everywhere at the foot of the back slopes of the central New Mexico ranges. They are 200 to 1,000 feet thick, and often form a conspicuous feature.

In the Sandia Mountains the lower sandstone is called the "Coyote" sandstone, from Coyote Springs. There is an upper shaly member representing the Cimarron.

JURASSIC-TRIASSIC SYSTEMS.

There appears to be but small doubt that the upper part of the great formation long called the "Red Beds" belongs to a later geologic age than the Carboniferous, and the portion which occurs in New Mexico appears to be that termed in Kansas the Cimarron formation.

In New Mexico these beds are largely developed in the northeastern part in Cimarron, Canadian, and Pecos valleys, and in the central part in the Rio Grande Valley. The thickness probably is not greatly in excess of 500 feet.

CRETACEOUS SYSTEM.

The formations of Cretaceous age are the most extensive surface rocks in New Mexico, as they probably cover more than one-half of the whole area. Both the upper and lower Cretaceous sediments are well represented, but the serial sequence has not yet been definitely made out. The Jornada is everywhere immediately underlain by these rocks and they are the principal water carriers. In Canadian and Pecos valleys, particularly around the western and northern borders of the Llano Estacado, a remarkable sequence of sands, chalky rocks, and clays lies above the "Red Beds." These strata, comprising the Trinity sands, Fredericksburg limestone, and Washita sands, are thought not to be present in the district here described, and the Cretaceous begins with a formation believed to be the Dakota sandstone. This formation is at least 300 feet in thickness in this region and its basal sandstone is one of the chief water reservoirs. While not generally recognized, except in northeastern New Mexico,

A. INTERNATIONAL RESERVOIR SITE. 2¼ MILES ABOVE INTERNATIONAL DAM SITE.

B. RIVER BED AT INTERNATIONAL RESERVOIR SITE.

View taken from big bend in river.

it is probable that the Dakota is widely distributed and is to be found a short distance above the "Red Beds."

Although clearly differentiated in northeastern New Mexico in particular, the Colorado formation is not so well defined to the southward. It comprises, chiefly, shales with numerous bands of limestone and several thick sandstones.

Attaining a development of 1,500 feet in northeastern New Mexico, the Montana shales will doubtless be found to be well represented elsewhere in the Territory. Certain beds in the Jornada district are thought to be the equivalents of this formation. The shales are mostly gray and drab, becoming yellowish above and blackish below.

In New Mexico the beds generally referred to the Laramie formation are about 2,000 feet in thickness. The rocks are chiefly gray sandstones and shales, with numerous beds of coal. Most of the Cretaceous of the region between the San Andreas and Caballos ranges seems to belong to this age.

TERTIARY AND QUATERNARY SYSTEMS.

Eocene.—None of the sediments of the Jornada are as yet known to belong to the Eocene. In the bordering region of the Rio Grande Valley, however, there are large areas of gray shales and clays, reaching a maximum thickness of over 800 feet, which have been referred to the early Tertiary and are called the Puerco formation. A large vertebrate fauna has been obtained from them.

Later Tertiary.—The later Tertiary beds are widely distributed over the plateau region. In eastern New Mexico the Llano Estacado formation, over 100 feet in thickness, appears to belong to this age. A considerable part of the sands and clay deposits underlying the bolsons doubtless belongs to the Tertiary, though as yet they have not been differentiated from the other unconsolidated deposits.

Quaternary.—To this age belong such beds as the bolson gravels, the arroyo gravels, alluvium, and many deposits of talus wash, besides some lake deposits.

The unconsolidated gravels and other surface deposits covering the plain of the Jornada del Muerto are probably in great part of comparatively recent origin. This opinion is based on the belief that the beveled plain itself is of Tertiary age, and that consequently the present topographic features are of recent date. The rock waste brought down from the mountain slopes and carried out into the plain is of comparatively recent origin and its deposition is still in progress. Apparently during Tertiary time the relief was less marked than at present, and if any deposits were spread on the plain at that time they were at best very meager.

The present unconsolidated surface deposits are of diverse origin. For the most part they are river deposits. Some are wind borne. A

few of very limited extent may be lake deposits, but of this there is no direct evidence in the Jornada, though in other basins there is ample evidence of extensive lake beds. There are some irregular beds which may be the fine, light débris known as volcanic ash, derived from some of the many volcanic outbursts in the region in later geologic time. These superficial deposits do not appear to have near the enormous thicknesses that have been ascribed to them, but in places they are several hundred feet thick.

Most of the basaltic lava flows of the region doubtless belong to the Quaternary period.

ERUPTIVE ROCKS.

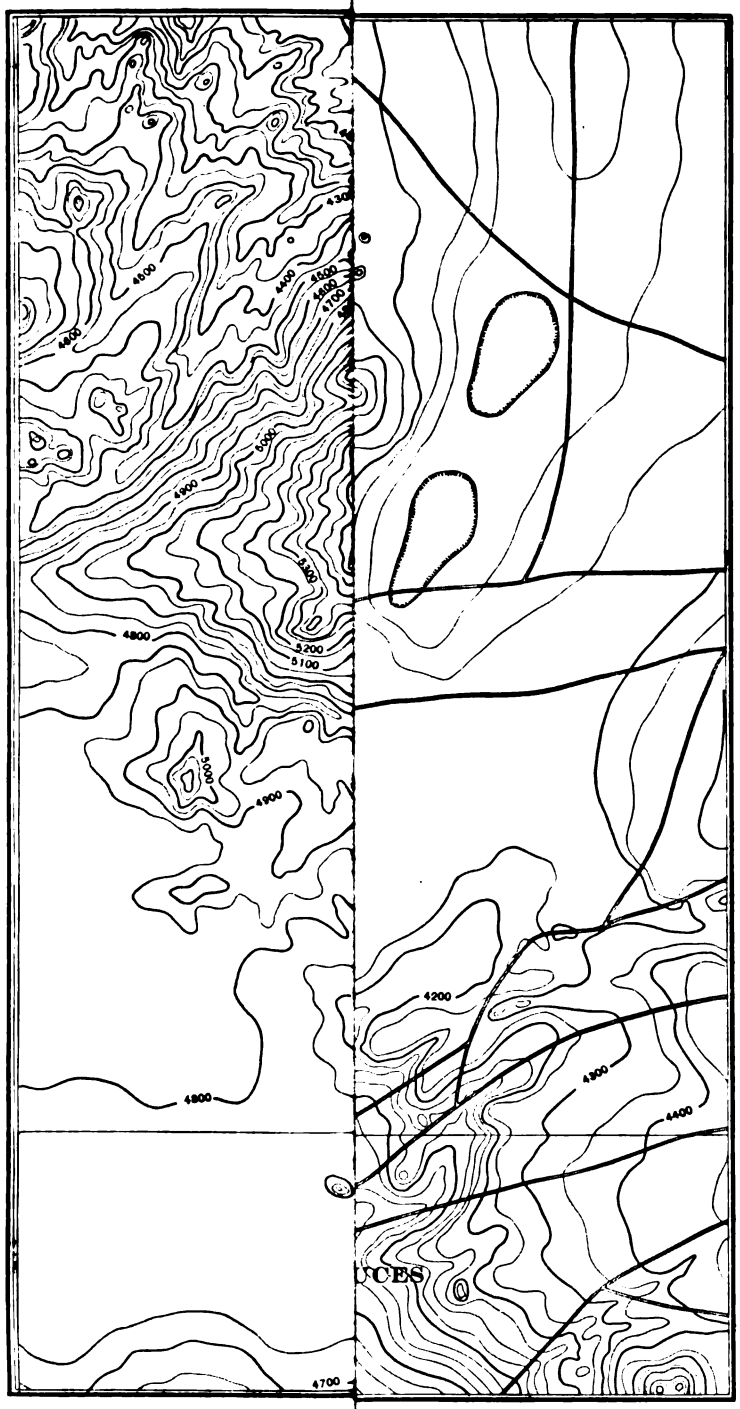
The eruptive rocks of the region are of three kinds. The most noteworthy are the surface flows of black basalt, which often cover many square miles. The great sheet which begins immediately south of San Marcial is perhaps the most extensive. It is of very late origin and lies on several hundred feet of soft materials. In the Rio Grande bluffs at San Marcial the lava capping is now 300 feet above the river. The bluffs at this point are nearly perpendicular and form a striking feature in the topography. This lava flow probably at one time dammed the river temporarily. Above the town terraces extend on either side of the river for many miles and gradually approach the water level in passing upstream.

Similar outflows from low volcanic cones occur at the northern end of the Jornada northwest of Ojo Chupadera. West of Engle station there are six or more low volcanic hills, none of them over 300 feet high, from which basalt flows extend for a distance of several miles. One cone 6 miles southwest of Engle appears to be the most important, as from it a broad tongue of lava extends a distance of 12 miles or more in a northwestward direction. This tongue is cut near its distal extremity by the deep Mescal Canyon. Four of these cones appear to be in a line running northeast and southwest. The rest are 5 to 6 miles apart.

Toward the north end of the line of volcanic cones there is one from which a broad sheet of lava extends into the Rio Grande Valley. Erosion has deeply dissected the river bluffs and has in several places isolated small areas of the original lava sheet which now form flat-topped hills rising several hundred feet above the stream. One of these isolated, lava-capped hills is widely known as Elephant Butte.

In the southern part of the plain, south of Afton, on the Southern Pacific Railroad, are similar lava flows covering many square miles of surface.

South of the Elephant Butte region the country is traversed by numerous basic dikes which are traceable for miles. So far as can be



A

From Las Cruces sheet 1900

ascertained these dikes do not materially affect the water conditions, at least so far as obtaining ample water supplies from shallow wells. In some situations springs issue from the strata in the vicinity of the dikes.

Of much older date are the trachytic and rhyolitic masses constituting the mountains near the point where the Rio Grande enters the Jornada. The San Diego Mountains and the Dona Ana Hills are all of this class. They rise abruptly out of the nearly level plain and form conspicuous features of the landscape.

On the northern rim of the Jornada near Ojo Chupadera the rocks are traversed by numerous nearly parallel dikes of trachyte. These dikes are 200 to 300 feet wide, trend northeast and southwest, are 2 to 4 miles apart, and are traceable for miles across the country. In the vicinity of the dikes the rocks have been considerably disturbed, and at some localities the plane of intrusion appears to be a fault, as narrow belts of Carboniferous limestone are brought up into contact with Cretaceous sandstone.

STRUCTURE.

GENERAL CHARACTERISTICS.

In its general structure the Jornada bolson is a section of a peneplain—part of a vast Tertiary grade plain—formed on the beveled edges of Mesozoic and Paleozoic strata (fig. 3). Through comparatively recent deformation the boundaries of the present bolson have been defined by locally intensified mountain uplift.

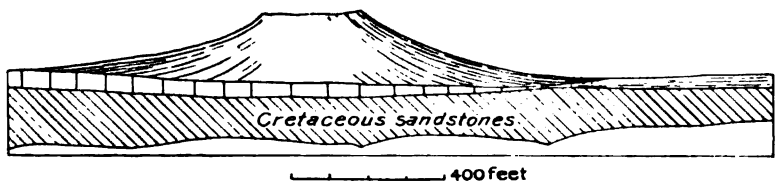


FIG. 3.—Mescal Cone resting on Cretaceous sandstones.

While in a general way the bolson under consideration is a broad, very shallow valley, and while with its rim abruptly upturned it has the appearance of a simple syncline, it is a district in which the synclinal structure has been developed at different times and under somewhat different conditions.

All the mountain ranges of central New Mexico may be considered as simple monoclinal blocks, so tilted as to present one steep side and an opposite side of more gentle slope. The crest and back slope of the different ranges consist chiefly of blue Carboniferous limestones. These limestones on the rim of the basin attain a thickness of over 1,000 feet, and are underlain by granites and gneiss.

In general structure, the ranges adjoining the great bolson plain of the Jornada del Muerto are of the characteristic mountain type known as the Basin Range structure. This feature is best illustrated by fig. 4, which is a cross section in an east-west direction transversely to the long axis of the bolson and embraces the mountain ranges on either side.

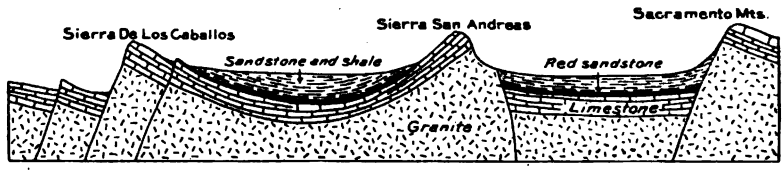


FIG. 4.—Basin Range structure of the Jornada.

In the various parallel bolsons and valleys which trend north and south through the high plateau region of New Mexico, the abrupt fault scarps on the sides face each other in some instances, while in others the longitudinal valleys are bounded by the long back slopes, giving the appearance of true synclines. The Jornada belongs in the main to the last-mentioned type. East of the Jornada is the great Jarilla bolson, a similar plain 150 miles long and 50 to 90 miles wide presenting opposed fault scarps on its longitudinal borders. To the west of the Jornada lies the Rio Grande Valley, which is similarly constructed, though now owing to the enormous erosion by the great stream the original plain effects are nearly obliterated. The general relations of the mountain blocks are more clearly represented in the cross sections in Pl. II. Near the mountains, especially on the west side of the plain, is a belt 3 to 4 miles wide, where the surface is trenched by intricately ramifying canyons, often several hundred feet deep, in which the formations are extensively exposed.

While the general slope of the plain toward the center is only 2° to 3°, the dips of the strata are often as high as 30° in the same direction, and in places they are vertical. On the beveled edges of the steeply inclined beds the plain gravels are laid down, and also broad sheets of basaltic lava, the latter spreading out from numerous low cones (see fig. 3).

The general synclinal character of the bolson holds good for only part of the Jornada. At its northern end the synclinal feature is completely lost. A monoclinal structure is present—steep on the western rim of the basin, but soon flattening out to nearly a dead level eastward to the foot of the Sierra Oscura, where there is a fault of 3,000 feet.

STRUCTURAL RELATIONS OF THE FORMATIONS.

The rim of the Jornada basin consists of limestones of Pennsylvanian age, which in the center of the synclinal trough lie beneath the sur-

A. ORGAN MOUNTAINS, NEW MEXICO, SHOWING A PORTION OF THE MOUNTAINS.

B. NATURAL DIKE NEAR ELEPHANT BUTTE.

face at a depth of more than 2,000 feet. Under these limestones are the crystalline schists and gneisses with intrusive granites. The formations to be considered with respect to the underground water conditions are those lying above the Carboniferous limestones and the overlying "Red Beds." These are the Cretaceous sandstones and the mantle of porous, unconsolidated deposits which everywhere cover the country occupied by this plain.

These several geologic terranes, embracing all between the basal crystallines and the loose surface deposits, recline upon one another without discordance in dip. It is possible that marked unconformities exist locally between some of the sedimentary rocks, but as yet no evidence of the existence of these conditions has been found.

DESCRIPTION OF CROSS SECTIONS.

The geologic cross sections of the Jornada are especially instructive in their direct bearing on the underground water conditions. Three of these cross sections (Pl. II) suffice to represent the general conditions. These are called the northern, middle, and southern cross sections, and their locations are indicated on the geologic map (Pl. I), although their extremities extend somewhat beyond the area shown on this map. Each of the cross sections is about 50 miles long. The vertical scale in feet is given at the side of the drawing, as are also the heights above sea level.

Northern cross section.—The northern section (section A–A on Pl. II), which may be called also the Socorro cross section, extends from the San Augustine Plains west of the Magdalena Mountains, through the old Socorro Volcano and the high range of hills on the east side of the Rio Grande, to beyond the Sierra Oscura. The Jornada lies between the last-mentioned range and the high hills bordering the Rio Grande on the east.

In this part of its extent the substructure of the Jornada plain is a monocline abutting against the Oscura Mountains. The latter rise abruptly out of the plain and for more than three-fourths of their height present crystalline rocks in the face of the escarpment they form.

Middle cross section.—The middle section (section B–B, Pl. II) may be called the Palomas section, since the famous Palomas Canyon which bisects the Sierra de los Caballos is in its line. This is the most typical cross section of the Jornada plain. It shows a simple synclinal structure, with profound faults on the opposite sides of the marginal mountain ranges in either direction.

On the Rio Grande side of the Caballos Range repeated faulting is indicated—the river occupying the minor fault block next to the great fault block of the main mountain ridge.

The highest part of the Caballos Range exhibits very clearly the evidences of a profound thrust plane, the geologic age of which greatly antedates the period of normal block faulting which gives the present characteristic aspect to the region. The Carboniferous limestones for three-fourths of the distance to the summit of the range stand nearly vertical. Erosion has beveled the edges of the upturned beds at angles of about 35°—the slope of the eastern side of range. This gives an appearance of great irregularity to the rocks, except at the top of the mountain, where horizontal beds cap the summit. The appearance is almost inexplicable until the existence of the fault thrust is recognized.

Immediately east of the western rim of the bolson and between the Sierra de los Caballos and Sierra Fra Cristobal are small lava cones 300 to 400 feet high, each of which has sent out a basaltic flow for several miles in all directions. These flows appear to cover some of the earlier mesa gravels, and they are probably early Pleistocene in age.

The gentle syncline of the Jornada is, perhaps, its most characteristic structural feature. It is to be noted, however, that this region is not a simple trough, but a syncline which has experienced repeated, or rather continued, upturning of its margins while the process of general base-leveling was going on.

In the San Andreas Range there is found a simple monoclinal block with profound faulting on the eastern flank of the range. From the foot another broad bolson plain extends to the lofty Sierra Blanca.

Southern cross section.—The Las Cruces section (Pl. II, section C–C) presents a number of features not displayed in the other two sections here mentioned. The Jornada continues to be a synclinal trough, but the Rio Grande has cut across the disturbed zone of the western rim and traverses the great bolson itself.

The Organ group of mountains, which forms a part of the eastern rim of the Jornada basin, is a mass of old crystalline rocks which, on account of special local conditions, has been thrust upward much more than any other part of the plain's periphery, and has been completely denuded of the sedimentary rocks, except at the very base of the range. Rising abruptly out of the plain half way between the Organ Mountains and the Rio Grande is Tortugas Hill, a small tilted limestone block.

SOME MINOR STRUCTURAL FEATURES.

The region to which this report relates exhibits many details of structure that probably are of sufficient interest to merit special notice here. Among the phenomena of this kind to be mentioned are faulting, jointing, folding, and fissuring. Most of the features are in the rim of the basin, and on the east slope of the Sierra de los Caballos are exemplifications of many interesting structural details.

Reversed faulting.—There is abundant evidence that while the present mountain uplifts are the products of normal faulting, this region has been subjected to some tangential pressure, causing overthrust faults. These occurred long after Carboniferous time, because they involve rocks of that age. Possibly some of the main lines of uplift of the present mountain ranges were initiated by the lines of weakness marked by the thrust planes.

In the Sierra de los Caballos the phenomena of reversed faulting are exceptionally well displayed. The east slope of the range presents some excellent examples on a small scale. One in which the throw is only 50 feet is represented in fig. 5.

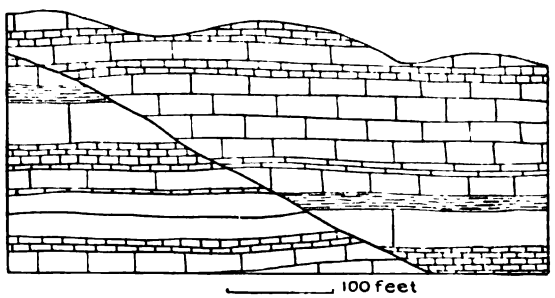


FIG. 5.—Small reversed fault in western rim of Jornada.

On the other hand, the immense thrust plane under the Caballos cone may represent a movement of one or more miles. It is clearly exposed, with relations shown in fig. 6.

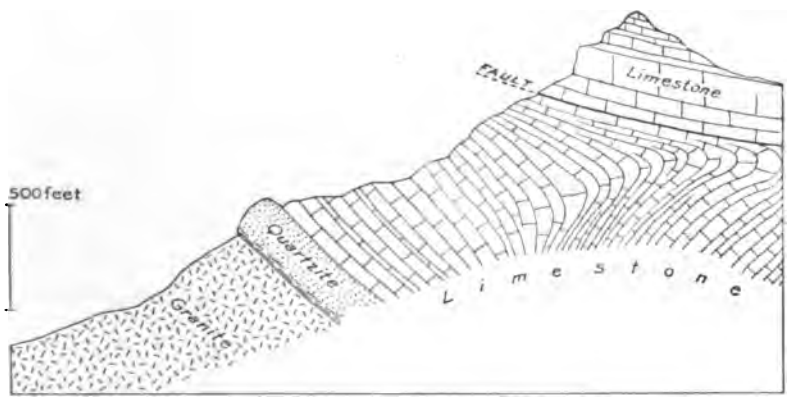


FIG. 6.—Caballos Peak and thrust plane.

The tremendous effects of the tangential pressure of this period are further indicated in Las Palomas Canyon, where the strata are greatly corrugated and folded.

Normal faulting.—The normal faults are of two series, of which the major produced the present monoclinal blocks forming the east

and west sides of the great basin. These have a throw of about 4,000 feet, and give the Basin Range structure to the region.

A minor series of normal faults trends at right angles to the axes of the mountain ranges. They were produced probably in the warping of the great limestone masses which form the main portions of the

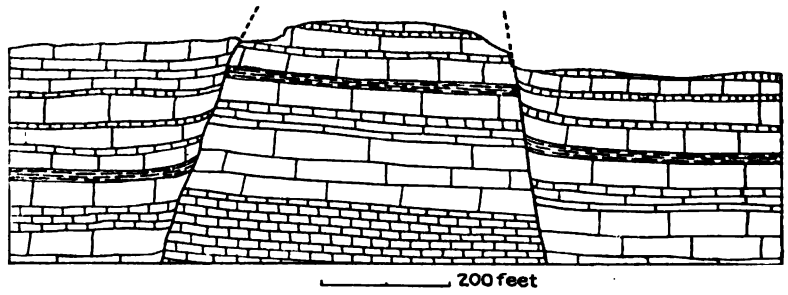


FIG. 7.—Normal faulting at Napoleon mine.

mountains. That some of these transverse faults, even those of comparatively small throw, affect great thicknesses of rock is shown by the fact that some of them are associated with true fissure veins of lead and copper ores. A cross section at the Napoleon mine is given in fig. 7.

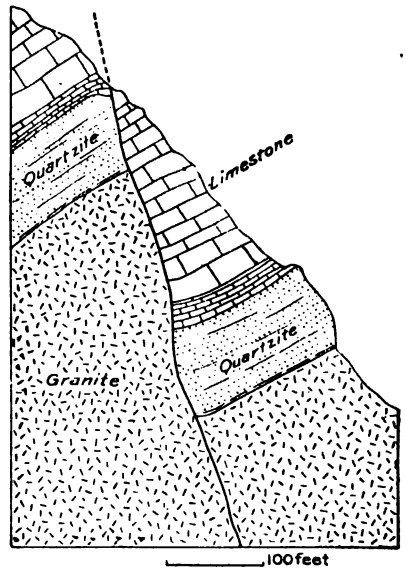


FIG. 8.—Normal faulting at El Capitan mine.

Another good illustration is at El Capitan mine, which is opened near the base of the unaltered sedimentary sequence, one side of the tunnel being the limestone and the other the crystalline complex (see fig. 8).

Another feature of faulting is associated with the basic dikes which extend for miles across the country east of the Caballos Range and near the volcanic cones already mentioned. In some cases the dikes do not appear to have disturbed the sandstones in which they occur, but simply spread apart the two walls. A good example is shown in Mescal Canyon, below the spring of the same name. This is represented in fig. 9.

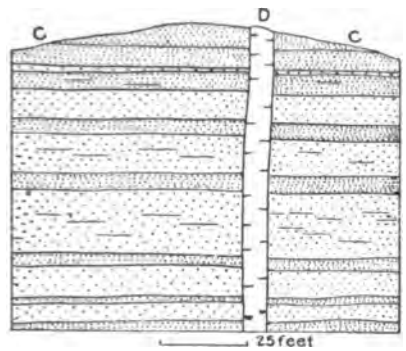


FIG. 9.—Basic dike in Cretaceous sandstone.

There are often springs issuing from the base of the canyon walls in the immediate vicinity of dikes of this description. It may be that the dikes act as dams for the underground waters and serve to pond them. On the other hand, some of these dikes greatly disturb the sandstones for a distance of several hundred feet. This is best illustrated by fig. 10.

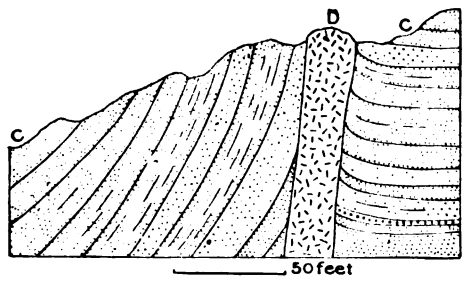


FIG. 10.—Basic dike disturbing level sandstones.

Still more prominent are some of the dikes on the northern border of the Jornada, east of the Ojo Chupadera. The relationships of the rocks are shown in fig. 11.

A similar dike is shown in Pl. IV, A, page 16. It cuts and upturns the Carboniferous limestones; but between the time of its intrusion and that of the deposition of the Cretaceous sandstones the whole region was elevated and beveled off.

In these cases the direct influence of the dikes in the local water storage underground is traceable. At various points springs issue from near the line of contact of the dike rock and sandstones. This

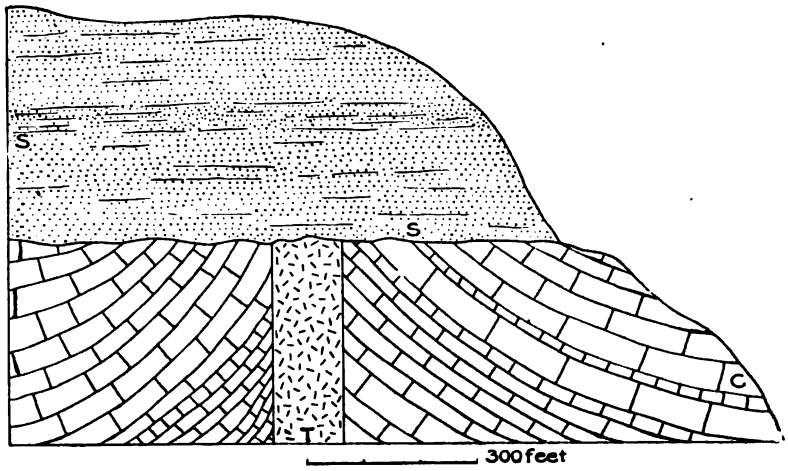


FIG. 11.—Acidic dike in Carboniferous limestones.

is especially noticeable wherever the rocks are slightly tilted. Reference will again be made to these various features in their bearings upon the local water supply.

UNDERGROUND WATERS.

GENERAL CONSIDERATIONS.

It will be seen from the foregoing description of the geologic relations that the Jornada del Muerto is underlain by extensive deposits of permeable materials. As the greater part of the rainfall sinks into these deposits, it is certain that they contain waters which are available for wells of greater or less depth. The appearance of a waterless waste which this plain presents loses much of its discouraging aspect to the settler when the real conditions are presented.

The peculiarities in geologic structure, composition and arrangement of materials, and climatic conditions of the Jornada are similar to those of the other bolson plains of the region, including western Texas. The observations of Hill[a] on the Texan area are so directly applicable to the area under consideration that several paragraphs are here quoted. He says:

> The influence of structure and imbibition is shown in the basin plains. Although unconsolidated, the rocks of the basin plains are alternations of porous and impervious beds, and hence are valuable artesian areas; by experimentation in boring in properly selected sites considerable water may be obtained. Nonflowing wells have

[a] Hill, R. T., Final Rept. Artesian and Underflow Investigation, U. S. Dept. Agric., pt. 3, 1892, p. 54.

been secured in many of the most unpromising plains, even in Death Valley; as furnishing water for stock, these wells are very important.

The geologic age of strata is of secondary importance in determining the occurrence of underground water. Approximately the same amount of rain falls upon a great diversity of country, some of which contains great stores of water, while other parts are entirely lacking in this essential. For instance, the mountains of the trans-Pecos region are mostly composed of hard, impervious rocks—compact limestones, quartzites, and eruptive rocks. Less than 1 per cent of the rain falling upon these rocks is absorbed, except such as finds its way into the structure by cracks and fissures or along lines of contact. As a result of this condition the water after every shower quickly flows down the slopes to the extensive flats which occupy the valleys between the mountain ranges. These flats, as well as the entire surface of the Llano Estacado, have a structure entirely different from the adjacent mountains, and are for the most part composed of loose, porous sands and gravels, so that every drop of rain that touches their surface is immediately absorbed and does not flow off in streams. This explains the utter absence of running water on the surface of these flats and its abundance stored in the structure beneath. Not only does this basin and plain formation imbibe all the rain which falls upon its surface, but the great torrents which pour down the mountain sides and canyons disappear immediately upon reaching the plain, being imbibed by its porous structure. The constant streams also which flow from the snow-clad peaks or mountain springs, such as the Seven Rivers, the Tularosa, and the numerous lost rivers of New Mexico and Texas, quickly disappear upon reaching the plain.

After the rain ceased an observer would be impressed by the fact that the representative rocks of the different areas exhibited capacities different not only for imbibing water, but also for transmitting it through their structure by percolation, and those rocks which imbibe the least water, like the limestones, porphyries, and quartzites of the Organ, the Guadalupe, and other trans-Pecos mountains, most slowly transmitted it, so that for days, perhaps months, springs and seeps flow from the crevices and contact plains of the high mountain slopes, keeping alive delicate ferns and rare plants. On the surface of the Llano, except where slight quantities of clay are mixed with sandy loam, in an hour or two there remains little evidence in the dry surface that a shower has fallen, the water having quickly penetrated to the depths beneath.

AREAL DISTRIBUTION OF THE WATER-BEARING BEDS.

By reference to the geologic map (Pl. I) the areal distribution of the several geologic formations will be seen. The greater part of the area is underlain by Cretaceous sandstone, which occupies the middle portion of the Jornada, probably four-fifths of the plains, and is more than 25 miles wide in places. On either side is a belt a mile or two broad of "Red Beds," chiefly impervious clays. Then come the Carboniferous limestones, forming the rim of the basin in a belt about 6 miles wide. Except in the Sierra Oscura and the Organ Mountains, the crystalline rocks are exposed on the bolson side of the area.

These various belts of formations extend in nearly parallel strips along nearly the entire length of the Jornada del Muerto district. Their proper recognition is necessary for an understanding of the hydrologic conditions to be expected in any particular part of the basin. This is especially true of the marginal portions of the area.

AREA OF WATER SUPPLY.

The most important feature to be taken into consideration in connection with the area of possible water supply is the fact that the collecting ground is not confined to the marginal mountains, as in many other regions, but the bolson imbibes all the water falling upon the surface. The underground reservoirs may be at different geologic horizons and at different depths from the surface, but, with the exception of a comparatively small amount of water which finds its way into the Rio Grande, all the rain finds lodgment in some part of the several porous formations.

As most of the mountain rock is hard and impervious, much of the rains run off the mountain slopes in torrents, which, as they spread out over the plain, are soon imbibed by the unconsolidated surface deposits. The arroyos of the Caballos Mountains carry streams 10 feet deep in time of heavy rainfall, flowing with terrific force and carrying away nearly all of the water, which is shed completely by the hard rocks on the mountain slopes. In the San Andreas Range these torrential waters are being stored for irrigation purposes in the adjacent plain below.

CLIMATIC CONDITIONS AFFECTING WATER SUPPLY.

As the Jornada is within the semiarid belt it presents characteristics not found in more humid regions. The total annual rainfall is about 12 inches, though in the mountainous rim, which rises 3,000 feet above the plain, the precipitation probably exceeds 15 inches a year.

The precipitation is mainly rain, but occasionally is in the form of snow, which covers the ground to a depth of 2 to 3 inches, but disappears in a few hours. Most of the rain falls during the months of July and August. Evaporation amounts to about 90 inches annually, and is facilitated by the dry air, high winds, and scant vegetation.

PERMEABLE STRATA.

One of the geologic peculiarities in the Jornada del Muerto is that it is in greater part overlain by unconsolidated porous deposits. These are the loose bolson gravels and sands which cover the underlying formations to considerable depth. Under fully two-thirds of the entire area of the plain the Cretaceous sandstones lie immediately beneath these bolson surface deposits. The next porous stratum is in the basal portion of the beds, where immediately above the Carboniferous limestones there often are beds of coarse sandstone.

There are, then, three distinct formations which permit the underground circulation of water. As these permeable formations extend throughout the whole Jornada, except a narrow belt around the mountainous rim, it is easy to understand the reason for the phenomenon of

a basin containing nearly 10,000 square miles, with an annual rainfall of 10 to 12 inches, yet having a total absence of running streams. Aside from the portion of rainfall which is evaporated, the whole of the annual precipitation is imbibed by the spongy surface formation, and percolates downward until it encounters some clayey layer or other impervious stratum.

WATER HORIZONS.

The water horizons in the three formations above described are as follows: (1) At the base of the bolson gravels, (2) at the base of the Cretaceous sandstones, and, locally, (3) at the base of the "Red Beds." These are the horizons from which artesian flows are most likely to be obtained. There are, however, other minor horizons in the bolson gravels and sands and Cretaceous sandstones, to which wells may be sunk to secure ample water supplies.

The depth to which it is necessary to bore in order to reach the base of the bolson gravels and sands, which form the first of the principal artesian horizons, varies greatly. The thickness of these gravels has manifestly been greatly overestimated, as all recent data indicate that they probably nowhere exceed a thickness of about 150 feet.

Shumard,[a] one of the pioneer scientists, who traversed the Jornada in 1856, makes the following statement:

> Wherever examined, the surface formation was found to consist of detritus of rock débris, in all respects the same as those composing the neighboring mountains from which it was doubtless mainly derived. The precise thickness of this deposit could not be very accurately determined, as only a few natural sections were observed and these only near the base of the mountains. In two localities its observed thickness was nearly 500 feet.
>
> Geologically speaking, the Jornada del Muerto may be considered as nothing more than a single trough composed mostly of limestones, sandstones, and shales, and covered to the depth of 500 or 600 feet with loose detritus.

There is no place along the Jornada in which there is a section of bolson gravels showing any very great thickness. As these gravels slope down from the marginal mountains, the first inference would naturally be that the incline was produced by filling up by the gravels on a level plain. This is not the case, for the gravels lie on a sloping surface and their thickness is not great along the slopes, as might at first glance be expected.

Waters from wells sunk in the Cretaceous sandstones are especially satisfactory. Most of the waters of the Jornada del Muerto now in use are "hard," as they often contain relatively large amounts of lime in the form of the carbonate and the sulphate, but the actual amounts of these compounds is surprisingly small when the source of the water is considered.

---

[a] Shumard, G. G., Structure of the Jornada del Muerto: Trans. St. Louis Acad. Sci., vol. 1, 1858, p. 341.

Some analyses of waters from an adjoining bolson, the Estancia plain, which presents almost identical geologic conditions, illustrate the point. These results of analyses are introduced for the reason that they represent even more extreme conditions than those in the Jornada. The analyses were made by Prof. F. C. Lincoln, of the New Mexico School of Mines.

Chemical analysis of well water at Stanley, N. Mex.

[In grains per United States gallon.]

Probable compounds:	
Organic and volatile matter	3.644
Silica	6.892
Alumina and ferric oxide	4.555
Calcium carbonate	4.163
Calcium sulphate	1.938
Calcium chloride	.000
Magnesium carbonate	3.052
Magnesium sulphate	.000
Magnesium chloride	.000
Potassium carbonate	.000
Potassium sulphate	2.973
Potassium chloride	.000
Sodium carbonate	.000
Sodium sulphate	2.708
Sodium chloride	4.194
Total solids	34.119

Chemical analysis of water of spring-fed lake at Estancia, N. Mex.

[In grains per United States gallon.]

Probable compounds:	
Organic and volatile matter	2.125
Silica	1.682
Alumina (with ferric oxide)	.666
Calcium carbonate	6.120
Calcium sulphate	8.332
Calcium chloride	.000
Magnesium carbonate	.000
Magnesium sulphate	.000
Magnesium chloride	4.463
Potassium carbonate	.000
Potassium sulphate	6.556
Potassium chloride	.000
Sodium carbonate	.000
Sodium sulphate	.000
Sodium chloride	2.371
Total solids	32.315

WELLS OF THE JORNADA DEL MUERTO.

The wells of the region are of three classes, viz, shallow dug wells, deep drilled wells, and flowing wells.

The first important well in the Jornada del Muerto was sunk by John Martin in 1871. He dug a hole 160 feet deep in the middle of the plain and found a plentiful supply of good water. From that time onward Martin's ranch became the stopping place of every party crossing the then dreaded basin.

During the more than thirty years which have passed since the first well was dug a large number of wells have been sunk in nearly every part of the region. They rarely go down more than 50 to 75 feet, and the water is raised chiefly by windmills.

When the location is selected with consideration of topographic and geologic conditions, it is quite likely that there are but few spots in the Jornada which would not furnish adequate supplies of water for all purposes to which the surrounding country is adapted. Most of the wells are now dug in the mesa gravels, but where they are in the Cretaceous sandstones there is apparently a larger flow, due probably to the more homogeneous texture and more uniform porosity of the formation.

It is probably unnecessary to mention in detail the various dug wells, as they are so numerous and the phenomena presented are so much alike everywhere within the area. Practically nothing has been done to develop water supplies by means of deep wells, though the conditions appear favorable for abundant water from this source. The only serious attempt to sink a deep well within the limits of the Jornada appears to have been at a point a short distance northwest of Engle, a station on the main line of the Atchison, Topeka and Santa Fe Railroad, on the high plain about halfway between San Marcial and Rincon. Engle is 300 feet above the first-named station and 700 feet above the second.

This well was drilled by the railroad company to a depth, as reported, of 1,200 feet. A good artesian flow was obtained, but the water was unfit for locomotives. The casing was withdrawn and the hole plugged at a depth of about 150 feet, where softer water is obtained. This water does not rise to the surface, but has to be pumped about 50 feet. The discharge goes into a large reservoir and is then piped to the station, about 2 miles distant. The present water supply appears to be obtained from the base of the mesa gravels. At a depth of 1,200 feet this boring probably failed to reach the base of the Cretaceous sandstones, the horizon in which artesian flows of good water may be expected.

A number of shallow wells are practically flowing wells. They have been dug near springs in some cases, and when properly curbed the

overflow is conducted through iron pipes farther down the valley. Such, for example, are some of the wells near the foot of the Caballos Range.

QUALITY OF THE UNDERGROUND WATERS.

In the arid regions the waters are so generally spoken of as "alkali waters" that many persons suppose that this character is the prevailing one. In most cases, however, the underground waters of such bolsons as the Jornada are often sufficiently good for domestic use. The so-called "alkali," which often appears as a thin white coating in places where the water has evaporated, in most cases consists chiefly of common salt. Of the large number of well waters examined from the Jornada comparatively few were found to be unpalatable and, with a few exceptions, all were excellent for stock and for domestic purposes.

RÉSUMÉ OF UNDERGROUND WATER PROSPECTS.

The geologic conditions of the Jornada indicate that the most important water-bearing stratum lies at the base of the Cretaceous sandstone. How extensive this stratum is can only be determined by a few properly located drill wells; but all available data lately collected go to show that this water supply should be very considerable.

Since the trough of the basin pitches southward about 12 feet to the mile, it is questionable whether the artesian conditions extend beyond the southern half of the region. The deep well and a number of shallow wells in the sandstone near Engle indicate that artesian conditions exist at least that far north.

The dips in the synclinal trough of the Jornada are such that the main water-bearing stratum lies from 1,000 to 2,000 feet beneath the surface in the center of the valley, but rises rapidly on each side until at a distance of from 10 to 12 miles on either side the water horizon reaches the surface under the gravels. The probable distance that it is necessary to drill in order to penetrate the principal water stratum may be thus estimated approximately. Moreover, there is another important and easily recognizable horizon which serves as a guide plane beyond which no one should go in his search for flowing water. The impervious "Red Beds" underlie the yellow sandstones of Cretaceous age and effectually prevent water from sinking lower. This important fact should always be borne in mind in sinking deep wells, and it is also believed to be useless to seek for water in the "Red Beds." When the drill penetrates these beds sufficiently to establish their identity the boring should be abandoned.

There are also local conditions that interfere with the artesian flow. Some of these obstructions have already been considered at length, but they should be regarded as of but limited extent and when met with a locality should not be condemned on account of a single failure.

The water-bearing stratum at the base of the mesa gravels is less clearly defined than that at the base of the Cretaceous sandstone. It is not likely to furnish flowing wells except in a few favored localities. Its main value is in furnishing the water supply for shallow, dug wells. Another point to be taken into consideration in connection with the water horizon of the mesa gravels is that in many places impervious clays separate the gravel beds. This brings important water-bearing levels much nearer the surface than would be ordinarily expected.

It is now a well-known fact that in the Mesilla Valley, where the Rio Grande traverses the Jornada plain, there is a vast underflow, from which water may be pumped in great volume for irrigation. As the Cretaceous sandstones rise near the surface in the Mesilla Valley, it is possible that a part of this underflow may be derived from the artesian stratum at the base of the Cretaceous sandstone, but it is here mainly in the Quaternary gravels filling the valley.

IRRIGATION.

Regarding the possibilities of the Jornada as a district for irrigation by well waters much might be written. It is possible that by systematic development many thousands of acres may be reclaimed for agricultural purposes. From artesian wells or even deep-drilled wells where pumping would have to be done, the outlook appears favorable for the irrigation possibilities. It is estimated that eventually at least one-tenth of the region should be brought under cultivation. The waters of the Rio Grande can be made available for the irrigation of large areas and the Elephant Butte reservoir at the end of the Sierra Fra Cristobal, now in contemplation, will bring an extensive portion of the flood plain under irrigation.

By the construction of reservoirs in the mountain arroyos along the elevated margin of the plain, many local areas may be brought under cultivation. Some of these reservoirs have already been planned or are under construction. Their success will certainly encourage many others to be built, and eventually a large strip of country bordering the mountain ranges, which at present is mostly used as grazing land, will thus be irrigated.

INDEX.

Page.

Afton, lava near 24
Algonkian rocks, occurrence and character of 18–20
Alkali, occurrence of 38
Archean rocks, occurrence and character of 18–19
Basalt, occurrence and character of 14, 24
Basin Range structure, figure showing 26
occurrence of 26
Bolsons, character of 11
meaning of name of 11
underground water in 32–39
Burlington limestone, correlation of 21
Burro Mountains, rocks of 19
Caballos, Sierra de los, dikes near 31
drainage of 34
faults in 28–29
figure showing 29
location of 16
rocks of 19
Canadian River, character of 12
rocks on 22
Canal, view of 20
Carboniferous rocks, dike in, figure showing 32
occurrence and character of 15, 18, 20–22, 25, 33
Cimarron formation, occurrence of 22
Cimarron River, rocks of 22
Chuar shales, occurrence of 20
Chupadero, Arroyo, location of 17
Chupadero Mesa, location of 15, 17
view of 16
Colorado formation, occurrence and character of 23
Colorado River, character of 12
Coyote sandstone, occurrence of 22
Cretaceous rocks, dike in, figure showing 31
occurrence and character of 15, 18–19, 22–23, 27, 33–34
wells in 35, 37–39
Dakota sandstone, occurrence and character of 22–23
Dikes, figures showing 31–32
occurrence of 31–32
Dona Ana Hills, location of 14, 17
rocks of 25
Drainage, character of 14, 17, 35
El Capitan mine, faulting at, figure showing 30
Elephant Butte, dike near, view of 26
dikes near 24–25
reservoir near 17, 39
view of 18

Page.

Engle station, volcanic cones near 14, 24
well near 37–38
Eocene rocks, occurrence of 23
Erosion, progress of 14, 16, 24
Estancia, spring water at, analysis of 36
Estancia bolson, location of 13, 17
Faulting, figures showing 29–30
occurrence and character of 29–30
Fort Selden, view near 16
Fra Cristobal, Sierra, location of 16
Franklin Mountains, location of 15, 18
Fredericksburg limestone, occurrence of 22
Geologic column, figure showing 18
Geologic formations, classes of 18
figure showing 18
occurrence and character of 18–25
permeability of 34–35
Geologic structure of region 25–32
Geology of region 18–32
Grand Canyon district, rocks of 20
Grand Canyon sandstone, occurrence of 20
Herrick, C. L., on Carboniferous of New Mexico 21
Hill, R. T., on bolsons 32–33
Igneous rocks, age of 19
occurrence and character of 14, 16–19, 24–25
International reservoir site, views of 22
Irrigation, prospects for 39
Jarilla bolson, location of 26
Jornada del Muerto, age of 13
area of 35
character of 10
location of 9–10
map showing 9
meaning of 10
view in 14
Journey of Death. *See* Jornada del Muerto.
Jurassic-Triassic rocks, occurrence of 22
Lake Valley, rocks of 21
Laramie formation, occurrence and character of 23
Lava, occurrence of 16–17
Lincoln, F. C., analyses by 36
Llano Estacado, area of 12
Llano Estacado formation, occurrence of 23
Madera limestone, occurrence of 22
Magdalena, Cerro, location of 16
Map, geologic, of region 10
Martin, John, well sunk by 11, 37
Mescal Canyon, dike in, figure showing 31
location and character of 16
Mescal Cone, section of, figure showing 25
Mesilla Valley, location and character of 13, 15, 17

	Page.
Mesilla Valley, underground water in	39
Mogollon Mountains, rocks of	19
Montana shales, occurrence and character of	23
Montosa, Cerro, location of	16
Muleros, Sierra de los, location of	18
Napoleon mine, faulting at, figure showing	30
New Mexico, geologic formations of	18
New Mexico plateau region, character and history of	11-13
Ojo Chupadero, rocks near	25
Organ Mountains, cliffs of, view of	14
location of	15
rocks of	28
views of	14, 20, 26
Oscura Range, location of	15
Paleozoic rocks, occurrence and character of	18, 20
Palomas Canyon, location and character of	16
Pecos River, character of	12
rocks on	22
Peña Blanca, location and character of	15
view of	14
Penasco Rock, view of	16
Pennsylvanian rocks, occurrence of	21, 26-27
Puerco formation, occurrence and character of	23
Quaternary rocks, occurrence and character of	18, 23-24
Rainfall, amount of	34
Red Beds, occurrence of	22, 33, 38
Reservoirs, storage, construction of	39
Rhyolite, occurrence of	25
Rio Grande, bolsons near	12-13
character of	12-13, 18
course of	17
irrigation from	39
reservoir site on, views of	22
Rio Grande, valley of, character of	26
Roblero, Cerro, location of	14, 17
San Andreas Range, location of	15
rocks of	20-21, 28
water of	34
San Diego Mountains, location of	14, 17
rocks of	25
San Marcial, rocks at	24
Sandia Mountains, rocks of	20-22
Sangre de Cristo ranges, rocks of	19
Sections, geologic, descriptions of	27-28
plate showing	12
Shumard, G. G., on Jornada del Muerto	35
Soledad Canyon, view of	18
Springs, occurrence of	31
Stanley, well water at, analysis of	36
Structure of region	25-32
Tertiary rocks, occurrence and character of	18-20, 24
Tonto formation, occurrence and character of	20
Topography of region	13-18
Trachite, occurrence of	25
Trinity sands, occurrence of	22
Unconformities, occurrence of	19
Vishnu quartzite, occurrence of	20
Volcanic cones, location of	14, 18, 25
Wallace, S. E., on Jornada del Muerto	10
Washita sands, occurrence of	22
Water, underground, analyses of	36
depth to	35, 38
extent of	34
horizons of	34-35, 38-39
occurrence of	11, 32-39
supply of, local obstructions to	38-39
Wells, classes of	37
sinking of	11, 37-38
water of, quality of	38

O

PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Water-Supply Paper No. 123.]

The serial publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of the United States—folios and separate sheets thereof, (8) Geologic Atlas of the United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

Most of the above publications may be obtained or consulted in the following ways:

1. A limited number are delivered to the Director of the Survey, from whom they may be obtained, free of charge (except classes 2, 7, and 8), on application.

2. A certain number are allotted to every member of Congress, from whom they may be obtained, free of charge, on application.

3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they may be had at prices slightly above cost.

4. Copies of all Government publications are furnished to the principal public libraries in the large cities throughout the United States, where they may be consulted by those interested.

The Professional Papers, Bulletins, and Water-Supply Papers treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous; H, Forestry; I, Irrigation; J, Water storage; K, Pumping water; L, Quality of water; M, General hydrographic investigations; N, Water power; O, Underground waters; P, Hydrographic progress reports. This paper is the sixty-sixth in Series B, and the thirty-sixth in Series O, the complete lists of which follow (PP=Professional Paper; B=Bulletin; WS=Water-Supply Paper):

SERIES B, DESCRIPTIVE GEOLOGY.

B 23. Observations on the junction between the Eastern sandstone and the Keweenaw series on Keweenaw Point, Lake Superior, by R. D. Irving and T. C. Chamberlin. 1885. 124 pp., 17 pls.

B 33. Notes on geology of northern California, by J. S. Diller. 1886. 23 pp. (Out of stock.)

B 39. The upper beaches and deltas of Glacial Lake Agassiz, by Warren Upham. 1887. 84 pp., 1 pl. (Out of stock.)

B 40. Changes in river courses in Washington Territory due to glaciation, by Bailey Willis. 1887. 10 pp., 4 pls. (Out of stock.)

B 45. The present condition of knowledge of the geology of Texas, by R. T. Hill. 1887. 94 pp. (Out of stock.)

B 53. The geology of Nantucket, by N. S. Shaler. 1889. 55 pp., 10 pls. (Out of stock.)

B 57. A geological reconnaissance in southwestern Kansas, by Robert Hay. 1890. 49 pp., 2 pls.

B 58. The glacial boundary in western Pennsylvania, Ohio, Kentucky, Indiana, and Illinois, by G. F. Wright, with introduction by T. C. Chamberlin. 1890. 112 pp., 8 pls. (Out of stock.)

B 67. The relations of the traps of the Newark system in the New Jersey region, by N. H. Darton. 1890. 82 pp. (Out of stock.)

B 104. Glaciation of the Yellowstone Valley north of the Park, by W. H. Weed. 1893. 41 pp., 4 pls.

B 108. A geological reconnaissance in central Washington, by I. C. Russell. 1893. 108 pp., 12 pls. (Out of stock.)

B 119. A geological reconnaissance in northwest Wyoming, by G. H. Eldridge. 1894. 72 pp., 4 pls.
B 137. The geology of the Fort Riley Military Reservation and vicinity, Kansas, by Robert Hay. 1896. 35 pp., 8 pls.
B 144. The moraines of the Missouri Coteau and their attendant deposits, by J. E. Todd. 1896. 71 pp., 21 pls.
B 158. The moraines of southeastern South Dakota and their attendant deposits, by J. E. Todd. 1899. 171 pp., 27 pls.
B 159. The geology of eastern Berkshire County, Massachusetts, by B. K. Emerson. 1899. 139 pp., 9 pls.
B 165. Contributions to the geology of Maine, by H. S. Williams and H. E. Gregory. 1900. 212 pp., 14 pls.
WS 70. Geology and water resources of the Patrick and Goshen Hole quadrangles in eastern Wyoming and western Nebraska, by G. I. Adams. 1902. 50 pp., 11 pls.
B 199. Geology and water resources of the Snake River Plains of Idaho, by I. C. Russell. 1902. 192 pp., 25 pls.
PP 1. Preliminary report on the Ketchikan mining district, Alaska, with an introductory sketch of the geology of southeastern Alaska, by A. H. Brooks. 1902. 120 pp., 2 pls.
PP 2. Reconnaissance of the northwestern portion of Seward Peninsula, Alaska, by A. J. Collier. 1902. 70 pp., 11 pls.
PP 3 Geology and petrography of Crater Lake National Park, by J. S. Diller and H. B. Patton. 1902. 167 pp., 19 pls.
PP 10. Reconnaissance from Fort Hamlin to Kotzebue Sound, Alaska, by way of Dall, Kanuti, Allen, and Kowak rivers, by W. C. Mendenhall. 1902. 68 pp., 10 pls.
PP 11. Clays of the United States east of the Mississippi River, by Heinrich Ries. 1903. 298 pp., 9 pls.
PP 12. Geology of the Globe copper district, Arizona, by F. L. Ransome. 1903. 168 pp., 27 pls.
PP 13. Drainage modifications in southeastern Ohio and adjacent parts of West Virginia and Kentucky, by W. G. Tight. 1903. 111 pp., 17 pls.
B 208. Descriptive geology of Nevada south of the fortieth parallel and adjacent portions of California, by J. E. Spurr. 1903. 229 pp., 8 pls.
B 209. Geology of Ascutney Mountain, Vermont, by R. A. Daly. 1903. 122 pp., 7 pls.
WS 78. Preliminary report on artesian basins in southwestern Idaho and southeastern Oregon, by I. C. Russell. 1903. 51 pp., 2 pls.
PP 15. Mineral resources of the Mount Wrangell district, Alaska, by W. C. Mendenhall and F. C. Schrader. 1903. 71 pp., 10 pls.
PP 17. Preliminary report on the geology and water resources of Nebraska west of the one hundred and third meridian, by N. H. Darton. 1903. 69 pp., 43 pls.
B 217. Notes on the geology of southwestern Idaho and southeastern Oregon, by I. C. Russell. 1903. 83 pp., 18 pls.
B 219. The ore deposits of Tonopah, Nevada (preliminary report), by J. E. Spurr. 1903. 31 pp., 1 pl.
PP 20. A reconnaissance in northern Alaska in 1901, by F. C. Schrader. 1904. 139 pp., 16 pls.
PP 21. The geology and ore deposits of the Bisbee quadrangle, Arizona, by F. L. Ransome. 1904. 168 pp., 29 pls.
WS 90. Geology and water resources of part of the lower James River Valley, South Dakota, by J. E. Todd and C. M. Hall. 1904. 47 pp., 23 pls.
PP 25. The copper deposits of the Encampment district, Wyoming, by A. C. Spencer. 1904. 107 pp., 2 pls.
PP 26. Economic resources of northern Black Hills, by J. D. Irving, with chapters by S. F. Emmons and T. A. Jaggar, jr. 1904. 222 pp., 20 pls.
PP 27. Geological reconnaissance across the Bitterroot Range and the Clearwater Mountains in Montana and Idaho, by Waldemar Lindgren. 1904. 122 pp., 15 pls.
PP 31. Preliminary report on the geology of the Arbuckle and Wichita mountains in Indian Territory and Oklahoma, by J. A. Taff, with an appendix on reported ore deposits in the Wichita Mountains, by H. F. Bain. 1904. 97 pp., 8 pls.
B 235. A geological reconnaissance across the Cascade Range near the forty-ninth parallel, by G. O. Smith and F. C. Calkins. 1904. 103 pp., 4 pls.
B 236. The Porcupine placer district, Alaska, by C. W. Wright. 1904. 35 pp., 10 pls.
B 237. Igneous rocks of the Highwood Mountains, Montana, by L. V. Pirsson. 1904. 208 pp., 7 pls.
B 238. Economic geology of the Iola quadrangle, Kansas, by G. I. Adams, Erasmus Haworth, and W. R. Crane. 1904. 83 pp., 1 pl.
PP 32. Geology and underground water resources of the central Great Plains, by N. H. Darton. 1905. 433 pp., 72 pls.
WS 110. Contributions to hydrology of eastern United States, 1904; M. G. Fuller, geologist in charge. 1905. 211 pp., 5 pls.
B 242. Geology of the Hudson Valley between the Hoosic and the Kinderhook, by T. Nelson Dale. 1904. 63 pp., 3 pls.
PP 34. The Delavan lobe of the Lake Michigan glacier of the Wisconsin stage of glaciation and associated phenomena, by W. C. Alden. 1905. 106 pp., 15 pls.

PP 35. Geology of the Perry basin in southeastern Maine, by G. O. Smith and David White. 1905. 107 pp., 6 pls.
B 243. Cement materials and industry of the United States, by E. C. Eckel. 1905. 395 pp., 1 pls.
B 246. Zinc and lead deposits of northeastern Illinois, by H. F. Bain. 1905. 56 pp., 5 pls.
B 247. The Fairhaven gold placers of Seward Peninsula, Alaska, by F. H. Moffit. 1905. 85 pp., 14 pls.
B 249. Limestones of southwestern Pennsylvania, by F. G. Clapp. 1905. 52 pp., 7 pls.
B 250. The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposit, by G. C. Martin. 1905. 64 pp., 7 pls.
B 251. The gold placers of the Fortymile, Birch Creek, and Fairbanks regions, Alaska, by L. M. Prindle. 1905. 89 pp., 16 pls.
WS 118. Geology and water resources of a portion of east central Washington, by F. C. Calkins. 1905. 96 pp., 4 pls.
B 252. Preliminary report on the geology and water resources of central Oregon, by I. C. Russell. 1905. 138 pp., 24 pls.
PP 36. The lead, zinc, and fluorspar deposits of western Kentucky, by E. O. Ulrich and W. S. Tangier Smith. 1905. 218 pp., 15 pls.
PP 38. Economic geology of the Bingham mining district of Utah, by J. M. Boutwell, with a chapter on areal geology, by Arthur Keith, and an introduction on general geology, by S. F. Emmons. 1905. 413 pp., 49 pls.
PP 41. The geology of the central Copper River region, Alaska, by W. C. Mendenhall. 1905. — pp. 20 pls.
B 254. Report of progress in the geological resurvey of the Cripple Creek district, Colorado, by Waldemar Lindgren and F. L. Ransome. 1904. 36 pp.
B 255. The fluorspar deposits of southern Illinois, by H. Foster Bain. 1905. 75 pp., 6 pls.
B 256. Mineral resources of the Elders Ridge quadrangle, Pennsylvania, by R. W. Stone. 1905. 86 pp., 12 pls.
B 257. Geology and paleontology of the Judith River beds, by T. W. Stanton and J. B. Hatcher, with a chapter on fossil plants, by F. H. Knowlton. 1905. 174 pp., 19 pls.
PP 42. Geology of the Tonopah mining district, Nevada, by J. E. Spurr. 1905. — pp., 23 pls.
WS 123. Geology and underground water conditions of the Jornada del Muerto, New Mexico, by C. R. Keyes. 1905. 42 pp., 9 pls.

SERIES O, UNDERGROUND WATERS.

WS 4. A reconnaissance in southeastern Washington, by I. C. Russell. 1897. 96 pp., 7 pls.
WS 6. Underground waters of southwestern Kansas, by Erasmus Haworth. 1897. 65 pp., 12 pls.
WS 7. Seepage waters of northern Utah, by Samuel Fortier. 1897. 50 pp., 3 pls.
WS 12. Underground waters of southeastern Nebraska, by N. H. Darton. 1898. 56 pp., 21 pls.
WS 21. Wells of northern Indiana, by Frank Leverett. 1899. 82 pp., 2 pls.
WS 26. Wells of southern Indiana (continuation of No. 21), by Frank Leverett. 1899. 64 pp.
WS 30. Water resources of the lower peninsula of Michigan, by A. C. Lane. 1899. 97 pp., 7 pls.
WS 31. Lower Michigan mineral waters, by A. C. Lane. 1899. 97 pp., 4 pls.
WS 34. Geology and water resources of a portion of southeastern South Dakota, by J. E. Todd. 1900. 34 pp., 19 pls.
WS 53. Geology and water resources of Nez Perces County, Idaho, Pt. I, by I. C. Russell. 1901. 86 pp., 10 pls.
WS 54. Geology and water resources of Nez Perces County, Idaho, Pt. II, by I. C. Russell. 1901. 87–141 pp.
WS 55. Geology and water resources of a portion of Yakima County, Wash., by G. O. Smith. 1901. 68 pp., 7 pls.
WS 57. Preliminary list of deep borings in the United States, Pt. I, by N. H. Darton. 1902. 60 pp.
WS 59. Development and application of water in southern California, Pt. I, by J. B. Lippincott. 1902. 95 pp., 11 pls.
WS 60. Development and application of water in southern California, Pt. II, by J. B. Lippincott. 1902. 96–140 pp.
WS 61. Preliminary list of deep borings in the United States, Pt. II, by N. H. Darton. 1902. 67 pp.
WS 67. The motions of underground waters, by C. S. Slichter. 1902. 106 pp., 8 pls.
B 199. Geology and water resources of the Snake River Plains of Idaho, by I. C. Russell. 1902. 192 pp., 25 pls.
WS 77. Water resources of Molokai, Hawaiian Islands, by W. Lindgren. 1903. 62 pp., 4 pls.
WS 78. Preliminary report on artesian basins in southwestern Idaho and southeastern Oregon, by I. C. Russell. 1903. 53 pp., 2 pls.
PP 17. Preliminary report on the geology and water resources of Nebraska west of the one hundred and third meridian, by N. H. Darton. 1903. 69 pp., 43 pls.
WS 90. Geology and water resources of a part of the lower James River Valley, South Dakota, by J. E. Todd and C. M. Hall. 1904. 47 pp., 23 pls.
WS 101. Underground waters of southern Louisiana, by G. D. Harris, with discussions of their uses for water supplies and for rice irrigation, by M. L. Fuller. 1904. 98 pp., 11 pls.

WS 102. Contributions to the hydrology of eastern United States, 1903, by M. L. Fuller. 1904. 522 pp.
WS 104. Underground waters of Gila Valley, Arizona, by W. T. Lee. 1904. 71 pp., 5 pls.
WS 106. Water resources of the Philadelphia district, by Florence Bascom. 1904. 75 pp., 4 pls.
WS 110. Contributions to the hydrology of eastern United States, 1904; M. L. Fuller, geologist in charge. 1904. 211 pp., 5 pls.
PP 32. Geology and underground water resources of the central Great Plains, by N. H. Darton. 1904. 433 pp., 72 pls
WS 111. Preliminary report on underground waters of Washington, by Henry Landes. 1904. 85 pp., 1 pl.
WS 112. Underflow tests in the drainage basin of Los Angeles River, by Homer Hamlin. 1904. 55 pp., 7 pls.
WS 114. Underground waters of eastern United States: M. L. Fuller, geologist in charge. 1904. 285 pp., 18 pls.
WS 118. Geology and water resources of east-central Washington, by F. C. Calkins. 1905. 96 pp., 4 pls.
B 252. Preliminary report on the geology and water resources of central Oregon, by I. C. Russell. 1905. 138 pp., 24 pls.
WS 120. Bibliographic review and index of papers relating to underground waters published by the United States Geological Survey, 1879–1904, by M. L. Fuller. 1905. 128 pp.
WS 122. Relation of the law to underground waters, by D. W. Johnson. 1905. 55 pp.
WS 123. Geology and underground water conditions of the Jornada del Muerto, New Mexico, by C. R. Keyes. 1905. 42 pp., 9 pls.

The following papers also relate to this subject: Underground waters of Arkansas Valley in eastern Colorado, by G. K. Gilbert, in Seventeenth Annual, Pt. II; Preliminary report on artesian waters of a portion of the Dakotas, by N. H. Darton, in Seventeenth Annual, Pt. II; Water resources of Illinois, by Frank Leverett, in Seventeenth Annual, Pt. II; Water resources of Indiana and Ohio, by Frank Leverett, in Eighteenth Annual, Pt. IV; New developments in well boring and irrigation in eastern South Dakota, by N. H. Darton, in Eighteenth Annual, Pt. IV; Rock waters of Ohio, by Edward Orton, in Nineteenth Annual, Pt. IV; Artesian well prospects in the Atlantic coastal plain region, by N. H. Darton, Bulletin No. 138.

Correspondence should be addressed to

THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, D. C.

AUGUST, 1905.

LIBRARY CATALOGUE SLIPS.

[Mount each slip upon a separate card, placing the subject at the top of the second slip. The name of the series should not be repeated on the series card, but the additional numbers should be added, as received, to the first entry.]

Author.

Keyes, Charles Rollin, 1864–

. . . Geology and underground water conditions of the Jornada del Muerto, New Mexico, by Charles Rollin Keyes. Washington, Gov't print. off., 1905.

42, v p. illus., IX pl. (incl. map), diagrs. 23cm. (U. S. Geological survey. Water-supply and irrigation paper no. 123)

Subject series: B, Descriptive Geology, 66; O, Underground waters, 36.

1. Geology—New Mexico. 2. Water, Underground—New Mexico.

Subject.

Keyes, Charles Rollin, 1864–

. . . Geology and underground water conditions of the Jornada del Muerto, New Mexico, by Charles Rollin Keyes. Washington, Gov't print. off., 1905.

42, v p. illus., IX pl. (incl. map), diagrs. 23cm. (U. S. Geological survey. Water-supply and irrigation paper no. 123)

Subject series: B, Descriptive Geology, 66; O, Underground waters, 36.

1. Geology—New Mexico. 2. Water, Underground—New Mexico.

Series.

U. S. Geological survey.

Water-supply and irrigation papers

no. 123. Keyes, C. R. Geology and underground water conditions of the Jornada del Muerto, New Mexico. 1905.

Reference.

U. S. Dept. of the Interior.

see also

U. S. Geological survey.

Water-Supply and Irrigation Paper No. 124 Series P, Hydrographic Progress Reports, 29

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

REPORT

OF

PROGRESS OF STREAM MEASUREMENTS

FOR

THE CALENDAR YEAR 1904

PREPARED UNDER THE DIRECTION OF F. H. NEWELL
BY
H. K. BARROWS and JOHN C. HOYT

PART I.—Atlantic Coast of New England Drainage

WASHINGTON
GOVERNMENT PRINTING OFFICE
1905

CONTENTS.

	Page.
Letter of transmittal	7
Introduction	9
Cooperation and acknowledgments	18
St. John River drainage basin	20
Fish River at Wallagrass, Me	21
Aroostook River at Fort Fairfield, Me	23
St. Croix River drainage basin	26
St. Croix River at Sprague's Falls, near Baring, Me	27
Machias River drainage basin	31
Machias River near Whitneyville, Me	31
Penobscot River drainage basin	34
Penobscot River at Millinocket, Me	36
Penobscot River at West Enfield, Me	37
Penobscot River (East Branch) at Grindstone, Me	40
Mattawamkeag River at Mattawamkeag, Me	44
Piscataquis River near Foxcroft, Me	47
Cold Stream at Enfield, Me	50
Phillips Lake and outlets in Dedham and Holden, Me	52
Kennebec River drainage basin	55
Kennebec River at The Forks, Me	56
Kennebec River near North Anson, Me	59
Kennebec River at Waterville, Me	62
Moose River near Rockwood, Me	64
Roach River at Roach River, Me	65
Dead River near The Forks, Me	66
Carrabassett River at North Anson, Me	67
Sandy River near Madison, Me	71
Messalonskee River at Waterville, Me	72
Cobbosseecontee River at Gardiner, Me	73
Androscoggin River drainage basin	74
Androscoggin River at Errol dam, N. H	75
Androscoggin River at Gorham, N. H	76
Androscoggin River at Shelburne, N. H	76
Androscoggin River at Rumford Falls, Me	78
Androscoggin River near Dixfield, Me	78
Presumpscot River drainage basin	80
Presumpscot River at outlet of Sebago Lake, Me	80
Saco River drainage basin	81
Saco River near Center Conway, N. H	82

	Page.
Merrimac River drainage basin	85
Merrimac River at Franklin Junction, N. H	86
Merrimac River at Garvins Falls, New Hampshire	89
Merrimac River at Lawrence, Mass	89
Pemigewasset River at Plymouth, N. H	93
Contoocook River at West Hopkinton, N. H	101
Suncook River at East Pembroke, N. H	105
Sudbury River at Framingham and Lake Cochituate at Cochituate, Mass	105
Nashua River (South Branch) at Clinton, Mass	108
Blackstone River drainage basin	109
Blackstone River at Woonsocket, R. I	109
Thames River drainage basin	111
Shetucket River near Willimantic, Conn	112
Connecticut River drainage basin	113
Connecticut River near Orford, N. H	115
Connecticut River at Sunderland, Mass	120
Connecticut River at Hartford, Conn	121
Israel River (above South Branch) near Jefferson Highlands, N. H	123
Israel River (below South Branch) near Jefferson Highlands, N. H	125
Ammonoosuc River at Bretton Woods, N. H	128
Zealand River near Twin Mountain, N. H	131
Little River near Twin Mountain, N. H	134
White River at Sharon, Vt	136
Ashuelot River at Winchester, N. H	138
Deerfield River at Deerfield, Mass	140
Ware River near Ware, Mass	142
Ware River at Gilbertville, Mass	143
Quabog River at West Warren, Mass	144
Swift River at West Ware, Mass	144
Westfield River at Russell, Mass	145
Housatonic River drainage basin	147
Housatonic River at Gaylordsville, Conn	147
Index	153

ILLUSTRATIONS.

	Page.
PLATE I. Map showing location of principal gaging stations in the United States	10
II. Price current meters, with buzzers	12
FIG. 1. Cable station, showing section of the river, car, gage, etc.	11

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
HYDROGRAPHIC BRANCH,
Washington, D. C., March 16, 1905.

SIR: I transmit herewith the manuscript of Part I of a series of twelve papers which compose the Report of Progress of Stream Measurements for the Calendar Year 1904. Parts I to VI of this report contain the results of the data collected in the territory east of Mississippi River. Parts VII to XII are devoted to the data collected in the territory west of Mississippi River.

The larger part of the original data for this report was collected under the direction of district hydrographer H. K. Barrows, who was assisted by S. K. Clapp, F. E. Pressey, and T. W. Norcross. The assembling of the data and its preparation for publication were done under the direction of John C. Hoyt, who has been assisted by R. H. Bolster, Robert Follansbee, Willis E. Hall, A. H. Horton, and H. D. Padgett.

I request that this manuscript be published as one of the series of Water-Supply and Irrigation Papers.

Very respectfully,

F. H. NEWELL, *Chief Engineer.*

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

PROGRESS REPORT OF STREAM MEASUREMENTS FOR THE CALENDAR YEAR 1904.

PART I.

By H. K. Barrows and John C. Hoyt.

INTRODUCTION.

The hydrographic work of the United States Geological Survey includes the collection of facts concerning and the study of conditions affecting the behavior of water from the time it reaches the earth as rain or snow until it joins the oceans or great navigable rivers. These investigations became a distinct feature of the work of the Survey in the fall of 1888, when an instruction camp was established at Embudo, N. Mex. Since that date the work has been continually and gradually extended as larger funds became available. The first distinctive appropriation for gaging streams was made by the act of August 18, 1894, which contained an item of $12,500, "for gaging the streams and determining the water supply of the United States, including the investigation of underground currents and artesian wells in the arid and semiarid sections." (Digest of Appropriations for 1895, p. 270.)

Since that time a similar act has been passed each year and the appropriations have gradually increased, as shown in the following table:

Annual appropriations for hydrographic surveys.

Year ending June 30, 1895	$12,500
Year ending June 30, 1896	20,000
Year ending June 30, 1897	50,000
Year ending June 30, 1898	50,000
Year ending June 30, 1899	50,000
Year ending June 30, 1900	50,000
Year ending June 30, 1901	100,000
Year ending June 30, 1902	100,000
Year ending June 30, 1903	200,000
Year ending June 30, 1904	200,000
Year ending June 30, 1905	200,000
Year ending June 30, 1906	200,000

The chief feature of the work of the hydrographic division is the systematic study of the flow of the surface waters and the conditions

affecting the same. In this connection other information that may be of use to the engineer or others in hydrographic studies, such as river profiles, duration and extent of damage by floods, water-power data, etc., is collected. Furthermore, the work has been so directed that the information collected will be of direct value in the commercial and agricultural development of the country.

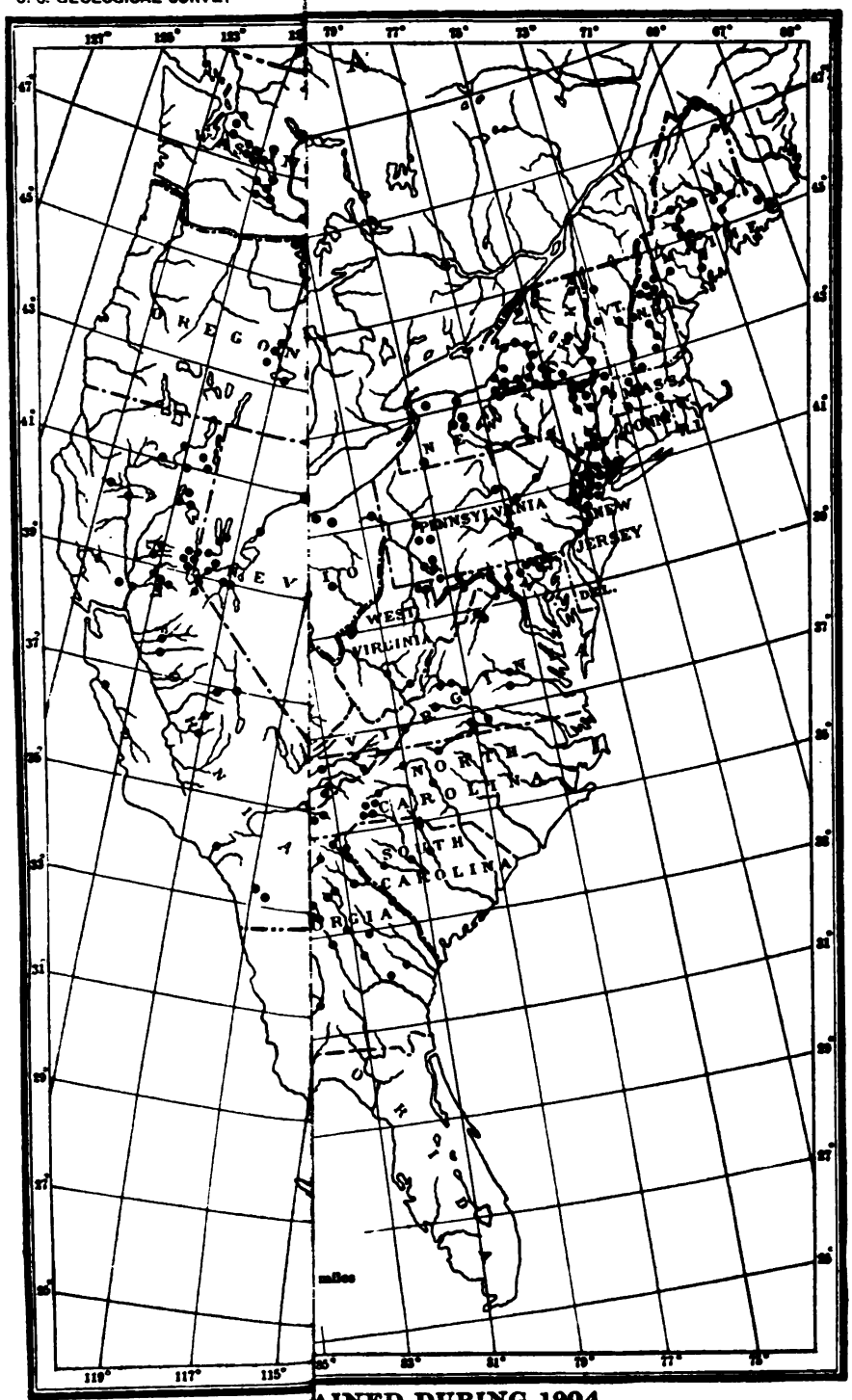
As a result of the increased appropriations since June 30, 1902, the work has been largely extended and thoroughly systemized. The various States have been grouped into districts, each of which is under the supervision of a district hydrographer who, with a corps of assistants, devotes his whole time to the study of the hydrographic resources of his district.

The methods used in the collection of these data and in their preparation for publication are given in detail in Water-Supply Paper No. 94. (Hydrographic manual, U. S. Geol. Survey.)

The general plan of stream gaging which has been developed is to obtain eventually data in regard to the flow of all the important streams in the United States. With this in view gaging stations are established at points where the data will be of greatest commercial value. At these stations discharge measurements are taken from time to time at typical river stages, and the daily surface fluctuation is obtained by means of gage readings. From these two factors it is possible to estimate both the total flow and its distribution through the period of observations.

The selection of the site for a gaging station and the length of time the station is maintained depend largely upon the needs of each locality. If the stream is to be used for water power, special efforts are made to obtain information concerning the low-water flow. If water is to be stored, the high waters are given special attention. In all sections certain permanent stations are maintained for general statistical purposes to show the conditions which exist through long periods. They also act as primary stations, and are used in connection with short series of measurements to determine the flow in particular portions of the drainage basin.

Gaging stations are divided into two general classes: First, current-meter stations; and second, weir stations. The former class is subdivided as to location into bridge, cable, boat, and wading stations. Fig. 1 shows a cable station with car, tag-line, inclined gage, etc. In addition to the bridge, cable, or boat, the equipment of a current-meter gaging station consists in a gage for determining the daily fluctuations of the water surface, bench marks to which the zero of the gage is referred, and permanent marks on the bridge or a tagged line indicating the points of measurement. Where the current is swift some appliance—generally a secondary cable—is necessary to hold the meter in position below the surface.



MAINED DURING 1904.

Gaging stations are generally located at bridges, if the channel conditions are satisfactory, as from them the meter can be easily manipulated, and the cost of the equipment is comparatively small. The stations are located as far as possible at points where the channel is straight, both above and below the gaging section, and where there are no cross currents, backwater, or boils. The bed of the stream should be as clear as possible from large projections and of a permanent character. The banks should be high, and should overflow at high stages only. Great care is taken in the selection and equipment of gaging stations, in order that the data may have the required degree of accuracy.

On many of the larger rivers where water power is developed by dams estimates of flow are obtained by observing the head on the crest and using a weir formula. On the smaller streams sharp-crested weirs are in some cases erected.

The principal instrument used in stream-measurement work is the current meter, by which the velocity of the flow of water is determined.

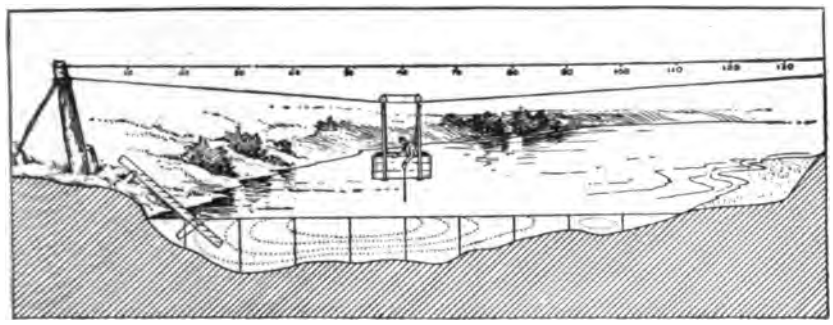


FIG. 1.—Cable station, showing section of river, car, gage, etc.

After years of experience the Survey has adopted the Price current meter for general work. This meter, as is shown on Pl. II, is made in two sizes, known as the large and small Price. The small Price has been largely developed by the officers of the Survey, using the Price acoustic meter as a basis.

A discharge measurement is the determination of the quantity of water flowing past a certain point at a given time. This quantity is the product of two factors: (1) The mean velocity, which is the function of the cross section, surface slope, wetted perimeter, and roughness of bed; (2) the area, which depends upon the permanency of the bed and the fluctuations of the surface, which govern the depth.

In making the measurement an arbitrary number of points are laid off perpendicular to the thread of the stream (see fig. 1). These points are usually at regular intervals, varying from 2 to 20 feet, depending upon the size and conditions of the stream. They are known as measuring points, and at them the observed data, the velocities and sound-

ings, are taken. The perpendiculars dropped from the measuring points divide the gaging section into strips, and for each strip or pair of strips the mean velocity, area, and discharge are determined independently; thus conditions existing in one part of the stream are not distributed to parts where they do not apply.

The methods of obtaining velocity with the current meters which are in general use may be grouped into three classes: Single point, multiple point, and integration.

The single-point method consists in holding the meter either at the depth of the thread of mean velocity, or at an arbitrary depth, for which the coefficient for reducing to mean velocity has been determined. Extensive experiments by vertical velocity-curves show that the thread of mean velocity lies at from 0.5 to 0.7 of the total depth. In general practice the thread of mean velocity is considered to be at 0.6 depth, and it is at this depth that the meter is held in the majority of the measurements, this being known as the six-tenth depth method. It is found by a large number of vertical velocity-curve measurements, taken on various streams and under various conditions, that the coefficient for reducing the velocity obtained at six-tenths depth to mean velocity is practically unity, ranging, in a series of 910 measurements made at 39 gaging stations, between 0.94 and 1.04, with a mean for the 910 observations of 1.00. In the other principal single-point method the meter is held near the surface, usually 1 foot below, or low enough to be out of the action of the wind or other disturbing influences. This is known as the subsurface method. The coefficient for reducing the velocities taken at the subsurface has been found by repeated experiments with vertical velocity-curves to be from 0.85 to 0.95, depending upon the depth of the stream and velocity and channel conditions. This method is specially adapted for flood measurements, or when the velocity is so great that the meter can not be kept at 0.6 depth.

The three principal multiple-point methods in general use are: The vertical velocity-curve; top and bottom; and top, bottom, and mid depth. In the vertical velocity-curve method a series of velocity determinations are taken in the vertical at regular intervals, usually from 0.5 to 1 foot apart. By plotting these velocities as abscissas and their depths as ordinates, and drawing a smooth curve through these points, the vertical velocity-curve is produced, which shows the change in velocity from the surface to the bottom of the stream. The mean velocity in the vertical is then obtained by dividing the depth into the area bounded by this mean velocity-curve and the initial line. Owing to the length of time it takes to make these measurements, they are seldom used except for determining coefficients for purposes of comparison, and for measurements under ice.

PRICE ELECTRIC CURRENT METERS, WITH BUZZERS.

In the second multiple-point method the meter is held from 0.5 to 1 foot below the surface and about 0.5 foot above the bottom, and the mean of the velocities at these two points is taken as the mean velocity for that vertical. This method is not well adapted for general work, as the roughness of the bottom disturbs the velocity at that point. For shallow streams with comparatively smooth beds good results are obtained by this method. In the third multiple-point method the meter is held at mid depth, at 0.5 foot below the surface and at 0.5 foot above the bottom, and the mean velocity is determined by dividing the sum of the top velocity twice the mid-depth velocity, and the bottom velocity by 4.

The vertical integration method consists in moving the meter at a slow, uniform speed from the surface to the bottom and back again to the surface. The number of revolutions and the time taken in the operation is noted, and the mean velocity is found by dividing the number of revolutions by the number of seconds taken in the run. This method has the advantage in that the velocity at each point of the vertical is measured twice. It is well adapted for measurements under ice and as a check on the point methods.

The area, which is the other factor for determining the discharge of the stream, depends upon the stage of the river, which is taken on a gage, and the general contour of the bed of the stream, which is found by sounding. The soundings are usually taken at each measuring point at the time of the discharge measurement, either by using the meter and cable or by a special sounding line or rod. For stations with permanent beds standard cross sections are usually taken during low water. These sections serve to check the soundings which are taken at the time of the measurements, and from them any change which may have taken place in the bed of the stream can be detected. They are also used for obtaining the area for use in computations of high-water measurements, as accurate soundings are hard to obtain at high stages.

In computing the discharge measurements from the observed velocities and depths at the various points of measurements the measuring section is divided into elementary strips, as shown in fig. 1, and the mean velocity, area, and discharge are determined separately for either a single or double strip. The total discharge and area are the sums of those for the various strips, and the mean velocity is obtained by dividing the total discharge by the total area.

The volume of water flowing in a stream is known as run-off. In expressing it various units are used, depending upon the kind of work for which the data are needed. Those used in this report are "second-feet," "acre-feet," "run-off per square mile," and "run-off in depth in inches," and may be defined as follows:

"Second-foot" is an abbreviation for cubic foot per second, and is the body of water flowing in a stream 1 foot wide, 1 foot deep, at a rate of 1 foot per second.

The "acre-foot" is the unit of capacity used in connection with storage for irrigation work, and is equivalent to 43,560 cubic feet. It is the quantity required to cover an acre to a depth of 1 foot. There is a convenient relation between the second-foot and the acre-foot; 1 second-foot flowing for twenty-four hours will deliver 86,400 cubic feet, which equals 1.9835 acre-feet, or, approximately, 2 acre-feet.

The expression "second-feet per square mile" means the average number of cubic feet of water flowing each second from every square mile of drainage area, on the assumption that the run-off is uniformly distributed.

"Depth in inches" means the depth of water in inches that would have covered the drainage area, uniformly distributed, if all the water could have accumulated on the surface. This quantity is used for comparing run-off with rainfall, which quantity is usually given in depth in inches.

It should be noticed that "acre-feet" and "depth in inches" represent the actual quantities of water which are produced during the periods in question, while "second-feet," on the contrary, is merely a rate of flow per second.

The base data for computing the daily discharge of a stream are the daily gage heights and the various discharge measurements, of which there should be sufficient number to cover the range of stage. The fundamental laws upon which these computations are based are the following:

(1) The discharge will remain constant so long as the conditions at or near the gaging station remain constant;

(2) Neglecting the change of slope due to the rise and fall of the stream, the discharge will be the same whenever the stream is at a given stage; and

(3) The discharge is both a function of, and increases gradually with, the gage heights (2 and 3 depend on 1).

As the beds of many streams are changeable, the problem divides itself into two classes: (1) Those of streams with permanent or practically permanent beds, and (2) those of streams with changeable beds. The base data and methods of obtaining them are the same for either class, and it is only in the computation of the mean daily flow that different methods are necessary.

In determining the daily discharge of streams with permanent beds, the results of the discharge measurements are plotted on cross-section paper, with gage heights as ordinates and discharges as abscissas. Through these points a smooth curve is drawn, which shows the discharge for any gage height, and from which a rating table is prepared. The mean velocity and area determined for each discharge measurement are also plotted. Through these points the curves of mean

velocity and of area are drawn, and the rating curve is largely determined by taking the product of the mean velocity and the area at various stages as determined by these curves. These curves of mean velocity and area are of special value in determining the location of the rating curve for stages at which actual discharge measurements are not available and for extending the discharge curve outside the limits of the measurements. In the preparation of the rating table the discharge for each tenth or half-tenth on the gage is found from the curve. The first and second differences of these discharges are then taken and adjusted according to the law that they shall either be constant or increasing, never decreasing. The discharges in the table are then changed in accordance with these adjusted differences. In making up the station rating curve, the individual discharge measurements and the conditions under which they were taken are carefully studied, in order that proper weight shall be given to each measurement. Rating curves in general take the form of a parabola, and as a rule the high-water portion of the curve approaches a straight line. For stations of permanent character, the results of the measurements from year to year should be within 5 per cent of the curve, with the exception of those taken during high water, when the probable error may be as high as 10 per cent.

The determination of the daily discharge of streams with changeable beds is difficult, and unless frequent discharge measurements are made, the results obtained are only roughly approximate. For streams with continually shifting beds, such as Colorado River and the Rio Grande, discharge measurements are made every two or three days, and the discharges for the intervening days are obtained by interpolation, modified by the gage heights for these days. For stations with beds which shift slowly, or are only materially changed during floods, station rating curves and tables can be prepared for the periods between changes, and satisfactory results can be obtained with two or three measurements a month, providing measurements are taken soon after the changes occur.

In determining the flow for periods when the streams are frozen, special rating curves and tables have to be prepared from measurements taken under these conditions. The methods of constructing these curves and tables are the same as for open sections. The discharge measurements, however, are taken either by integration in verticals or by the vertical velocity-curve method, as sufficient experiments have not been made on ice-covered streams to determine the laws which govern the position of the thread of mean velocity.

The Report of Progress of Stream Measurements for the Calendar Year 1904, of which this is Part I, is published in a series of twelve Water-Supply Papers, Nos. 124–135, inclusive, under the subtitles following.

Part 1. Atlantic coast of New England drainage.
Part 2. Hudson, Passaic, Raritan, and Delaware River drainages.
Part 3. Susquehanna, Patapsco, Potomac, James, Roanoke, Cape Fear, and Yadkin River drainages.
Part 4. Santee, Savannah, Ogeechee, Altamaha rivers, and Eastern Gulf of Mexico drainage.
Part 5. Eastern Mississippi River drainage.
Part 6. Great Lakes and St. Lawrence River drainage.
Part 7. Hudson Bay, Minnesota, Wapsipinicon, Iowa, Des Moines, and Missouri River drainages.
Part 8. Platte, Kansas, Meramec, Arkansas, and Red River drainages.
Part 9. Western Gulf of Mexico drainage.
Part 10. Colorado River and Great Basin drainage.
Part 11. The Great Basin and Pacific Ocean drainage in California.
Part 12. Columbia River and Puget Sound drainage.

The territory covered by each paper is given in the subtitle, and the larger drainages are, for convenience in arrangement, subdivided into smaller ones, under which the data are arranged, as far as practicable, geographically.

These papers contain the data that have been collected at the regular gaging stations, the results of the computations based upon the observations and such other information that has been collected that has a direct bearing on these data, including, as far as practicable, descriptions of the drainage areas and the streams draining them.

For each regular station are given, as far as available, the following data:

1. Description of station.
2. List of discharge measurements.
3. Gage-height table.
4. Rating table.
5. Table of estimated monthly and yearly discharges and run-off.

The descriptions of stations give, as far as possible, such general facts about the locality and equipment as would enable the reader to find the station and use the same. They also give, as far as possible, a complete history of all the changes that have occurred since the establishment of the station that would be factors in using the data collected.

The discharge-measurement table gives the results of the discharge measurements made during the year. This includes the date, the hydrographer's name, the gage height, and the discharge in second-feet.

The table of daily gage heights gives for each day the mean height of the surface of the river as found from the mean of the gage readings taken on that day. At most of the stations the gage is read in the morning and in the evening.

The rating table gives discharges in second-feet corresponding to each stage of the river as given by the gage heights.

In the table of estimated run-off the column headed "Maximum" gives the mean flow for the day when the mean gage height was the highest, and it is the flow as given in the rating table for that mean gage height. As the gage height is the mean for the day, there might have been short periods when the water was higher and the corresponding discharge larger than given in this column. Likewise in the column of "Minimum" the quantity given is the mean flow for the day when the mean gage height was lowest. The column headed "Mean" gives the average flow for each second during the month. Upon this mean the computations for the three remaining columns which are defined on page 14 are based.

In the computations for the tables of this report the following general and special rules have been used:

Fundamental rules for computation.

1. The highest degree of precision consistent with the rational use of time and money is imperative.

2. All items of computation should in general be expressed by at least two and by not more than four significant figures.

3. Any measurement in a vertical velocity, mean velocity, or discharge curve whose per cent of error is 5 times the average per cent error of all the other measurements should be rejected.

4. In reducing the number of significant figures, or the number of decimal places, by dropping the last figure, the following rules apply:

(a) When the figure in the place to be rejected is less than 5, drop it without changing the preceding figure. Example: 1,827.4 becomes 1,827.

(b) When the figure in the place to be rejected is greater than 5, drop it and increase the preceding figure by 1. Example: 1,827.6 becomes 1,828.

(c) When the figure in the place to be rejected is 5, and it is preceded by an even figure, drop the 5. Example: 1,828.5 becomes 1,828.

(d) When the figure in the place to be rejected is 5, and it is preceded by an odd figure, drop the 5 and increase the preceding figure by 1. Example: 1,827.5 becomes 1,828.

5. In constructing and applying rating tables a maximum limit of one-half per cent error should seldom be exceeded.

Special rules for computation.

1. Rating tables are to be constructed as close as the data upon which they are based will warrant. No decimals are to be used when the discharge is over 50 second-feet.

2. Daily discharges shall be applied directly to the gage heights as they are tabulated.

3. Monthly means are to be carried out to one decimal place when the quantities are below 100 second-feet. Between 100 and 10,000 second-feet, the last figure in the monthly mean shall be a significant figure. This also applies to the yearly mean.

4. Second-feet per square mile and depth in inches for the individual months shall be carried out at least to three significant figures, except in the case of decimals, where the first significant figure is preceded by one or more naughts (0), when the quantity shall be carried out to two significant figures. Example: 1.25; .125; .012; .0012. The yearly means for these quantities are always to be expressed in three significant figures and at least two decimal places.

The results of the stream measurements made during previous years by the United States Geological Survey can be found in the following

Survey publications. A detailed index of these reports is given in Water-Supply Paper No. 119.

1888. Tenth Annual Report, Part II.
1889. Eleventh Annual Report, Part II.
1890. Twelfth Annual Report, Part II.
1891. Thirteenth Annual Report, Part III.
1892. Fourteenth Annual Report, Part II.
1893. Bulletin No. 131.
1894. Bulletin No. 131; Sixteenth Annual Report, Part II.
1895. Bulletin No. 140.
1896. Water-Supply Paper No. 11; Eighteenth Annual Report, Part IV.
1897. Water-Supply Papers Nos. 15 and 16; Nineteenth Annual Report, Part IV.
1898. Water-Supply Papers Nos. 27 and 28; Twentieth Annual Report, Part IV.
1899. Water-Supply Papers Nos. 35 to 39, inclusive; Twenty-first Annual Report, Part IV.
1900. Water-Supply Papers Nos. 47 to 52, inclusive; Twenty-second Annual Report, Part IV.
1901. East of Mississippi River, Water-Supply Papers Nos. 65 and 75.
West of Mississippi River, Water-Supply Papers Nos. 66 and 75.
1902. East of Mississippi River, Water-Supply Papers Nos. 82 and 83.
West of Mississippi River, Water-Supply Papers Nos. 84 and 85.
1903. East of Mississippi River, Water-Supply Papers Nos. 97 and 98.
West of Mississippi River, Water-Supply Papers Nos. 99 and 100.
1904. East of Mississippi River, Water-Supply Papers Nos. 124 to 129, inclusive.
West of Mississippi River, Water-Supply Papers Nos. 130 to 135, inclusive.

A limited number of these are for free distribution, and as long as the supply lasts they may be obtained by application to the Director United States Geological Survey or to members of Congress. Other copies are filed with the Superintendent of Public Documents, Washington, D. C., from whom they may be had at prices slightly above cost. Copies of Government publications are, as a rule, furnished to the public libraries in our large cities, where they may be consulted by those interested.

COOPERATION AND ACKNOWLEDGMENTS.

Most of the measurements presented in this paper have been obtained through local hydrographers. Acknowledgment is extended to other persons and corporations who have assisted local hydrographers or have cooperated in any way, either by furnishing records of the height of water or by assisting in transportation.

The following list, arranged alphabetically by States, gives the names of the resident hydrographers and others who have assisted in furnishing and preparing the data contained in this report:

Connecticut.—Resident hydrographer, N. C. Grover, until July 1, after that time H. K. Barrows,[a] assisted by S. K. Clapp and T. W. Norcross. Acknowledgment should be made to Edwin D. Graves, chief engineer of the Connecticut River bridge and highway district, for gage heights of Connecticut River near Hartford.

[a] The office of the resident hydrographer for New England, 6 Beacon street, Boston, Mass.

Maine.—Resident hydrographer, N. C. Grover, until July 1, after that time H. K. Barrows; assisted by F. E. Pressey. Acknowledgments should be made to the Bangor and Aroostook Railroad and the Somerset Railroad for annual passes issued to N. C. Grover (later to H. K. Barrows) and F. E. Pressey; to the Maine Central Railroad for annual pass, good between Portland and Vanceboro, issued to N. C. Grover (later to F. E. Pressey), and to the Portland and Rumford Falls Railroad for trip passes issued when desired. Thanks are due to the following individuals and corporations for data furnished and assistance rendered: H. S. Ferguson, engineer for the Great Northern Paper Company, for furnishing data on flow of Penobscot River at Millinocket; Dr. L. S. Chilcott, of Bangor, for gage readings of Phillips Lake; Hollingsworth & Whitney Company, of Winslow, through James L. Dean, their engineer, for records of flow of the Kennebec at Waterville; C. S. Humphreys, C. E., of Madison, for assistance in installing gage at Madison electric plant on Sandy River, and the use of the plant for the purpose of procuring data on flow; the Chase Manufacturing Company, at Waterville, for the use of their dam on Messalonskee River for measurement purposes; Alex. H. Twombley, engineer for the Forest Paper Company, of Yarmouthville, for records of flow of the Cobbosseconteе; C. A. Mixer, engineer for the Rumford Falls Power Company, for records of flow of Androscoggin River at Rumford Falls; S. D. Warren & Co., of Westbrook, for records of flow of the Presumscot.

Massachusetts.—Resident hydrographer, N. C. Grover, until July 1; after that time, H. K. Barrows, assisted by S. K. Clapp and T. W. Norcross. Acknowledgments should be made to the Boston and Albany Railroad for pass, good between Boston and Pittsfield, issued to H. K. Barrows; R. A. Hale, principal assistant engineer of the Essex Company, Lawrence, for records of flow of Merrimac River at that point; Frederic P. Stearns, chief engineer of the Metropolitan Water and Sewerage Board, for records of flow of Sudbury and Nashua rivers and Lake Cochituate; X. H. Goodnough, chief engineer State Board of Health, for information regarding various streams in Massachusetts; the George H. Gilbert Manufacturing Company, of Ware, for assistance in procuring records of flow of Ware River at Gilbertville; the George H. Gilbert Manufacturing Company and the Otis Company, of Ware, for assistance in maintaining gaging station at Ware; John T. F. MacDonnell, of Holyoke, for the use of the dam at West Warren for measurement purposes; the West Warren Paper Company, through Dwight Holland, manager, for assisting in procuring data regarding flow of Swift River at West Ware.

New Hampshire.—Resident hydrographer, N. C. Grover, until July 1; after that time, H. K. Barrows, assisted by S. K. Clapp, F. E. Pressey, and T. W. Norcross. Acknowledgments should be made to the Maine Central and Boston and Maine Railroad for passes in New Hampshire, issued to N. C. Grover (later to H. K. Barrows) and S. K. Clapp; Walter H. Sawyer, agent of the Union Water Power Company, Lewiston, for assisting in procuring records of flow of Androscoggin River at Errol dam, and for other data concerning Androscoggin River; Hollis French, of French & Hubbard, Boston, for data regarding flow of the Merrimac at Garvins Falls and the use of this plant for measurement purposes; also to G. G. Shedd, resident engineer at this point, for assistance rendered. Measurements of Connecticut River at Orford were made in part by Prof. C. A. Holden, of Dartmouth College.

Rhode Island.—Resident hydrographer, N. C. Grover, until July 1; after that time, H. K. Barrows, assisted by S. K. Clapp and T. W. Norcross.

Vermont.—Resident hydrographer, N. C. Grover, until July 1; after that time, H. K. Barrows, assisted by S. K. Clapp and T. W. Norcross. Acknowledgments should be made to Profs. A. D. Butterfield and G. M. Brett, of the University of Vermont, for assistance rendered; to the Boston and Maine Railroad for passes issued to N. C. Grover (later to H. K. Barrows) and S. K. Clapp; to the Rutland Railroad for pass issued to H. K. Barrows, and to the St. Johnsbury and Lake Champlain Railroad for pass issued to H. K. Barrows.

ST. JOHN RIVER DRAINAGE BASIN.

St. John River drains the largest basin between St. Lawrence River on the north and Susquehanna River on the south. Its total drainage area is stated by Wells[a] to be 26,000 square miles, of which approximately 7,500 square miles lie in Maine, its basin occupying the whole northern portion of the State. The extreme headwaters lie in the mountainous region between Maine and Canada, at elevations of 1,500 and 2,000 feet; thence its waters flow at first generally northeasterly through Maine. From the point of junction of the northwest and southwest branches, where the river first takes its name, to its junction with St. Francis River, a distance of 90 miles, its course lies wholly in Maine, although a portion of the tributary area lies in Canada. In this distance Alleguash River is the only tributary of importance. Wells estimates the average slope in the 90 miles to be 1.6 feet per mile. From its junction with St. Francis River the St. John forms the northern boundary of Maine for 70 miles. Within this distance the slope is slightly greater than above, having been estimated to be 2.7 feet per mile, while the volume is considerably augmented by two important tributaries—Fish River from the south and Madawaska River from the north. At the point where it leaves the State line the river has an elevation of about 420 feet above sea level and drains an area of 8,765 square miles, of which 4,670 square miles are in Maine and 4,095 square miles in Canada. Beyond this point it receives the waters of Aroostook and Meduxnekeag rivers, the basins of which are almost entirely in Maine, besides several smaller tributaries having their sources, and in some cases a large portion of their drainage basins, in the same State.

The underlying rock is generally deep and either calcareous or clay slate. The basin is well forested; large areas have never been touched by the ax, while other portions have been lumbered for pine only. Probably 85 to 90 per cent of the whole basin tributary to the river at the eastern boundary of Maine is in forest.

According to Wells, the ponds and lakes in this basin in Maine aggregate a total surface area of 314 square miles. Of this water surface 120 square miles, or 38 per cent, are tributary to Alleguash River (36 square miles of which have been diverted to Penobscot River); 60 square miles, or 19 per cent, are tributary to Aroostook River; and 80 square miles, or 25 per cent, are tributary to Fish River. At the outlets of several of these lakes dams have been built which store water to be used in transporting logs.

Prior to 1845, a canal was cut from Telos Lake in the Alleguash basin to Webster Lake in the Penobscot basin, and a dam was constructed between Chamberlain and Eagle lakes. Thus, by means of

[a] Wells, Walter, The water power of Maine, 1869.

these artificial structures, Chamberlain Lake, with its drainage basin of 270 square miles, was made tributary to the Penobscot. This diversion of St. John water is still continued. During the log-driving season, which varies considerably in its duration, nearly all of the run-off from this area is thrown to the Penobscot, while during the remainder of the year the gates in the dam at Chamberlain Lake are opened and water is allowed to flow both ways. On account of the fact that the gates in the dam at the outlet of Chamberlain Lake are about 2 feet lower than those in the dam at Telos Lake, the flow from this basin to the St. John is greater than that to the Penobscot when the gates in both are open. As the surface of the lake is lowered the proportion flowing to the St. John increases until at extreme low water none flows to the Penobscot.

Both the upper St. John and Allegash rivers are generally inaccessible. The middle portion, forming the northern boundary of the State, may be reached on the Canadian side at any point by the Temiscouata Railroad, or in Maine at Fort Kent and Van Buren by the Bangor and Aroostook Railroad, while the basins of Fish and Aroostook rivers are rendered easily accessible by means of the latter road. The drainage areas of the stream and its principal tributaries are as follows:

Drainage areas of St. John River and principal tributaries.

River.	Locality.	Area.
		Square miles.
St. John	Below Allegash	4,320
Do	Eastern boundary of Maine	8,765
St. Francis	Mouth	580
Madawaska	do	1,085
Tobique	do	1,705
Allegash	do	1,500
Fish	do	910
Do	Wallagrass	890
Aroostook	Mouth	2,350
Do	Fort Fairfield	2,230
Meduxnekeag	Mouth	520

No measurements of flow of St. John River have been published. The United States Geological Survey maintains gaging stations in this basin on Fish River at Wallagrass, Me., and on Aroostook River at Fort Fairfield, Me.

FISH RIVER AT WALLAGRASS, ME.

Fish River enters the St. John from the south at Fort Kent. It has a total drainage area of 910 square miles, all of which lies in Maine, and of which 80 square miles are water surface. The basin is very

generally wooded, probably 75 or 80 per cent of its area being still in forest. Of the several available power sites one only is partially developed and used for the manufacture of lumber. The underlying rock is shale or slate, and in general is well covered by soil.

The gaging station at Wallagrass was established by N. C. Grover on July 29, 1903. It is located just below the outlet of Wallagrass Brook. The area of the drainage basin at this point is 890 square miles. A standard chain gage is attached to trees on the bank; length of chain, 39.75 feet. It is referred to bench marks as follows: (1) Copper bolt in ledge 600 feet downstream from gage; elevation, 11.73. (2) Nail driven in blazed birch tree 5 feet upstream from gage; elevation, 11.91 feet. Elevations refer to datum of gage. The measurements of flow are made from a cable located about 1,500 feet downstream from the gage, or by wading at low stages of the river. The channel is straight 500 feet above and 300 feet below the cable, and is about 100 feet wide. The bed is permanent and of gravel. The depth increases gradually from either bank to a maximum at low water of 3.5 feet near the center. The current at the cable is generally strong. At extreme low water the observed mean velocity was 0.63 of a foot per second. The banks are high and are not liable to overflow. The gage is read once a day by Vital E. Michaud, of Wallagrass.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Fish River at Wallagrass, Me., in 1903 and 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Square feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
September 18	F. E. Pressey	269	0.97	2.80	260
September 18	do	269	.97	2.80	261
October 20	do	53	2.80	2.40	148
October 20	do	208	.69	2.40	144
October 29	do	205	.63	2.13	129
October 29	do	33	3.30	2.06	109
November 12	do	241	.83	2.50	200
1904.					
May 5	F. E. Pressey	1,680	4.57	12.98	7,690
May 5	do	1,680	4.49	12.97	7,540
June 2	do	990	3.53	8.95	3,490
June 2	do	1,000	3.50	9.00	3,500
June 16	do	740	2.48	6.35	1,840
June 16	do	730	2.40	6.29	1,760
August 9	do	305	1.16	3.19	355
October 27	do	615	2.24	5.39	1,380

Mean daily gage height, in feet, of Fish River at Wallagrass, Me., for 1904.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	4.3	3.5	10.6	9.3	5.0	3.6	3.2	6.0	5.0	3.6
2	.....	4.3	3.3	11.2	8.0	4.9	3.4	3.2	6.0	5.0	[a]3.7
3	.....	4.3	3.1	12.3	8.8	4.8	3.4	3.3	6.1	4.9	3.8
4	.....	4.3	3.1	12.8	8.2	4.7	3.4	4.0	6.2	4.8	3.8
5	.....	4.3	3.2	13.2	8.1	4.8	3.3	4.2	6.4	4.7	3.7
6	.....	4.3	3.2	13.4	8.1	4.7	3.3	4.3	6.4	4.6	3.7
7	.....	4.3	3.2	13.6	8.0	4.6	3.2	4.3	6.3	4.6	3.6
8	.....	4.3	3.3	13.4	7.8	4.6	3.2	4.4	6.1	4.5	3.3
9	.....	4.4	3.3	13.2	8.0	4.4	3.2	4.4	6.1	4.4	3.3
10	.....	4.5	3.3	13.3	7.7	4.3	3.3	4.4	6.1	4.3	3.3
11	.....	4.7	3.6	13.4	7.0	4.2	3.4	4.4	6.1	4.4	[b]
12	.....	4.7	3.8	13.6	6.8	4.1	3.3	4.4	6.1	4.6	.....
13	.....	4.7	4.0	13.6	6.7	4.2	3.2	4.5	6.1	4.5	.....
14	4.2	4.7	4.2	13.4	6.6	4.5	3.3	4.6	6.0	4.3	.....
15	4.2	4.7	4.3	12.7	6.4	4.4	3.2	4.6	5.9	4.3	[c]5.2
16	4.2	4.6	4.4	12.4	6.4	4.4	3.2	4.7	5.9	4.2	.....
17	4.3	4.6	4.5	12.0	6.1	4.3	3.2	4.7	5.9	4.2	.....
18	4.3	4.6	4.6	11.8	6.1	4.2	3.2	4.7	5.9	4.0	.....
19	4.3	4.6	4.8	11.6	6.0	4.2	3.2	4.8	5.9	3.9	.....
20	4.3	4.6	5.0	11.4	5.7	4.1	3.2	5.0	5.8	3.8	.....
21	4.4	4.7	5.2	11.1	6.8	4.0	3.2	5.0	5.8	3.8	[d]4.4
22	4.5	4.8	5.4	10.9	6.0	3.9	3.2	5.0	5.8	3.7	.....
23	4.5	4.8	5.6	10.6	5.2	3.9	3.3	5.0	5.6	3.7	.....
24	4.3	4.8	5.9	10.4	5.3	3.9	3.3	5.1	5.6	3.7	.....
25	4.3	4.8	6.5	10.1	5.1	3.8	3.4	5.2	5.5	3.7	.....
26	4.3	4.7	7.2	10.0	4.9	3.8	3.4	5.2	5.5	3.7	.....
27	4.3	4.5	7.6	9.9	5.0	3.7	3.3	5.2	5.4	3.7	.....
28	4.3	4.3	8.0	9.6	5.3	3.7	3.3	5.2	5.3	3.6	.....
29	4.3	4.2	9.1	10.1	5.3	3.8	3.3	5.2	5.3	3.6	.....
30	.....	4.0	10.3	9.8	5.1	3.7	3.2	5.4	5.3	3.6	[e]4.2
31	.....	3.8	.....	9.2	.....	3.7	3.2	.....	5.0	.....	.....

[a] River frozen over. [b] Ice 0.5 foot thick.
[c] Ice 1.2 foot thick. [d] Ice 1.6 foot thick. [e] Ice 1.9 foot thick.

NOTE.—Gage readings through ice taken to surface of water in a hole cut in the ice.

AROOSTOOK RIVER AT FORT FAIRFIELD, ME.

Aroostook River enters the St. John from the west near Aroostook Junction in the province of New Brunswick. It has a total drainage area of 2,350 square miles, of which 2,320 square miles lie in Maine. Probably 80 per cent of the whole basin is in forest. The underlying rock is usually slate. Lake storage is used for driving logs only. Water power is used in Presque Isle. The principal falls on the river, known as Aroostook Falls, lie in Canada.

This gaging station was established by N. C. Grover on July 31, 1903. It is located at the steel highway bridge in the village of Fort Fairfield. The drainage area at this point is 2,230 square miles. A standard chain gage is attached to the steel webbing of the upstream truss; length of chain 27.61 feet. It is referred to bench marks as follows: (1) Northwest corner of south abutment, elevation 22.43 feet.

(2) Marked point on connection plate near gage, elevation 23.60 feet. Elevations refer to datum of gage. The initial point for soundings is on the right bank at the lower end of the inclined end post of the downstream truss. The channel is straight for at least 1,000 feet above and 1,000 feet below the station, and is about 350 feet wide, broken by three piers. The bed is of gravel and permanent. The banks are high and not liable to overflow. The current is medium at low water and swift at high water; the least observed mean velocity was 0.74 of a foot per second, at gage height 3.31 feet. The depths are small at low water, averaging about 2 feet. The gage is read twice daily by C. C. Harvey.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Aroostook River at Fort Fairfield, Me., in 1903 and 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Square feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
July 13	N. C. Grover	547	1.44	3.70	785
September 10	do	363	.74	3.31	270
October 27	F. E. Pressey	406	.80	3.36	326
1904.					
May 3	F. E. Pressey	4,690	5.94	13.33	27,900
May 10	do	3,050	5.24	10.02	16,000
May 25	do	2,180	4.62	8.21	10,100
May 25	do	2,100	4.58	8.05	9,620
June 4	do	1,220	3.48	5.75	4,250
June 14	do	1,030	3.21	5.34	3,310
August 11	do	428	.97	3.44	415
October 25	do	950	2.66	4.96	2,530

Mean daily gage height, in feet, of Aroostook River at Fort Fairfield, Me., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	.....	.....	12.80	6.90	5.50	3.95	3.50	6.35	4.90	3.90
2	.....	.....	.....	.....	13.60	6.50	5.20	3.85	3.55	6.95	4.80	4.20
3	.....	.....	.....	.....	13.25	6.15	5.35	3.80	3.60	6.85	4.70	4.30
4	.....	.....	.....	.....	12.55	5.80	5.65	3.70	3.95	6.45	4.60	4.30
5	.....	.....	[a]5.00	.....	12.35	6.15	5.70	3.70	5.55	6.10	4.55	4.20
6	.....	[b]4.10	.....	.....	12.75	6.30	5.60	3.70	6.05	5.85	4.50	4.10
7	.....	.....	.....	.....	12.55	6.65	5.10	3.60	5.75	5.65	4.50	4.30
8	.....	.....	.....	.....	11.90	6.80	4.80	3.60	5.30	5.50	4.35	4.35
9	5.10	.....	.....	.....	11.30	6.70	4.60	3.60	5.10	5.35	4.30	4.30
10	.....	.....	.....	.....	10.70	6.25	4.35	3.60	4.85	5.30	4.25	4.30
11	.....	.....	.....	.....	10.10	5.90	4.25	3.60	4.55	5.30	4.20	4.45
12	.....	.....	[c]5.20	10.50	9.90	5.80	4.05	3.55	4.40	5.40	4.05	4.55

[a] Ice 2.2 feet thick. [b] Ice 2.1 feet thick; gage height to top of ice=5.1 feet. [c] Ice 1.7 feet thick.

Mean daily gage height, in feet, of Aroostook River at Fort Fairfield, Me., for 1904—Con.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
13		a 4.10			9.50	5.70	4.05	3.60	4.35	5.35	4.00	4.35
14					8.95	5.40	4.35	3.65	4.20	5.15	4.10	4.20
15					8.95	5.15	4.90	3.70	4.20	4.95	4.30	4.20
16	5.20			10.10	8.85	4.95	4.95	3.80	5.35	5.10	4.00	4.10
17					8.60	4.80	4.65	3.85	6.10	5.05	3.95	b 4.10
18						4.65	4.50	3.80	5.95	4.95	4.10	
19			c 5.00	7.80		4.45	4.25	3.80	5.85	4.90	3.75	
20		d 4.10				4.45	4.20	3.85	5.80	4.85	3.75	
21						4.30	4.00	3.80	5.80	4.80	3.95	
22						4.15	4.00	3.90	5.65	4.80	4.05	
23	e 4.90					4.00	3.90	3.95	5.45	4.80	4.10	
24						3.95	3.75	3.90	5.25	4.95	3.90	f 4.10
25						4.10	3.70	3.85	5.20	5.05	3.90	
26						4.30	3.70	3.80	5.55	5.00	3.85	
27		c 5.00				5.95	3.75	3.65	5.80	5.00	3.90	
28						6.25	3.75	3.55	5.75	5.10	3.90	
29						5.75	3.75	3.50	5.55	5.15	4.20	
30	a 4.60			13.35		5.35	3.85	3.50	5.50	5.05	3.95	
31							3.90	3.50		5.00		g 4.10

a Ice 2 feet thick; gage height to top of ice=5 feet.
b Ice .2 foot thick.
c Ice 2.1 feet thick.
d Ice 2.2 feet thick; gage height to top of ice=5 feet.
e Ice 1.5 feet thick.
f Ice .8 foot thick.
g Ice 1.1 feet thick.

NOTE.—During frozen season gage readings are to surface of water in hole cut in ice. Ice floats normally on water except as noted.

Rating table for Aroostook River at Fort Fairfield, Me., from August 1, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.00	48	3.95	1,022	5.70	4,005	8.00	9,500
3.05	79	4.00	1,087	5.80	4,215	8.20	10,100
3.10	112	4.10	1,220	5.90	4,425	8.40	10,710
3.15	147	4.20	1,360	6.00	4,635	8.60	11,330
3.20	185	4.30	1,500	6.10	4,845	8.80	11,960
3.25	226	4.40	1,645	6.20	5,060	9.00	12,600
3.30	270	4.50	1,795	6.30	5,275	9.20	13,240
3.35	317	4.60	1,950	6.40	5,495	9.40	13,900
3.40	368	4.70	2,110	6.50	5,715	9.60	14,560
3.45	422	4.80	2,275	6.60	5,940	9.80	15,230
3.50	478	4.90	2,445	6.70	6,165	10.00	15,910
3.55	535	5.00	2,620	6.80	6,395	10.50	17,650
3.60	593	5.10	2,805	6.90	6,630	11.00	19,400
3.65	652	5.20	2,995	7.00	6,865	11.50	21,200
3.70	712	5.30	3,190	7.20	7,345	12.00	23,000
3.75	772	5.40	3,390	7.40	7,840	12.50	24,850
3.80	833	5.50	3,595	7.60	8,360	13.00	26,700
3.85	895	5.60	3,800	7.80	8,910	13.50	28,600
3.90	958						

The foregoing table is applicable only for open-channel conditions. It is based upon 11 discharge measurements made during 1903 and 1904. It is well defined between gage heights 3.30 feet and 13.30 feet. The table has been extended beyond these limits. Below gage height 3.3 feet the curve is very uncertain.

Estimated monthly discharge of Aroostook River at Fort Fairfield, Me., for 1903 and 1904.

[Drainage area, 2,230 square miles.]

Month.	Discharge in second-feet.			Run off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1903.					
August	1,290	368	641	0.287	0.331
September	1,087	226	473	.212	.236
October	422	79	217	.097	.112
November	2,110	270	910	.408	.455
December 1–14	1,645	317	1,100	.326	.170
1904.					
May 1–17	28,980	11,330	19,920	8.93	5.65
June	6,630	1,022	3,648	1.64	1.83
July	4,005	712	1,825	.818	.943
August	1,022	478	734	.329	.379
September	4,845	478	2,985	1.34	1.49
October	6,748	2,275	3,352	1.50	1.73
November	2,445	772	1,348	.604	.674
December 1–17	1,872	958	1,429	.641	.405

ST. CROIX RIVER DRAINAGE BASIN.

St. Croix River is formed by two branches; one, known as the upper St. Croix or Chiputneticook River, is the outlet of Schoodic Lakes; the other, Kennebasis River, is the outlet of the western lakes of the area, known as Kennebasis Lakes. The upper St. Croix, with its tributary lakes, forms nearly half of the eastern boundary of Maine, separating that State from New Brunswick. The total drainage area of the main stream is about 1,630 square miles, of which 920 square miles are tributary to the great reservoir systems controlled by dams at Vanceboro and Princeton. The length of the stream from the headwaters to the mouth is 100 miles. The basin is, in general, lower than that of any of the larger streams of the State flowing into the Atlantic, its headwaters having an elevation of about 540 feet. The fall from Chiputneticook (the lower of the Schoodic Lakes) to tide water, a distance of 54 miles, is, however, 382 feet, or 7 feet to the mile. At a number of places where falls and rapids occur water power has been or can easily be developed.

The lake surface of the upper St. Croix is approximately 50 square miles, and that of the West Branch 70 square miles in area, taking into account only the principal lakes and ponds. Indeed, above Vanceboro and Princeton, each branch of the river is simply a succession of lakes to almost the extreme headwaters. Wells estimated the total lake surface of the St. Croix as not less than 150 square miles, or nearly one-tenth of the total basin. The drainage area at various points on the river is given in the following table:

Drainage area of St. Croix River.

	Sq. miles.
Main river:	
Vanceboro dam, foot of the Schoodic Lakes	420
Little Falls	500
Immediately above mouth of West Branch	690
Immediately below mouth of West Branch	1,360
Spragues Falls	1,390
Calais, lower dam	1,530
Mouth of river, eastern border of town of Calais	1,630
West Branch:	
Princeton dam	500
Confluence with main river	670

A large proportion of the drainage basin is still covered with timber, and above Vanceboro and Princeton the region is for the most part wild and inaccessible. The greater part of the timber land in this region is controlled by sawmill owners at Calais and St. Stephen. In 1898 the amount of lumber sawed annually had decreased from about 100 million feet to 25 million feet, and since then the number of sawmills has been greatly reduced. In 1901 the lumber sawed amounted to 28 million feet, showing that the rate of cutting has remained nearly constant during the last few years. There are on this stream favorable locations for paper and pulp mills, but arrangements would have to be made with the sawmill owners in order to obtain a supply of timber.

The river is navigable as far as Calais, except during two months of the year, when it is frozen. Calais has railroad connection with Bangor directly over the Washington County Railroad, and, by way of Vanceboro, over the Canadian Pacific and the Maine Central railroads. There is also a short road connecting Princeton with Calais. Above Princeton the transportation facilities are poor.

ST. CROIX RIVER AT SPRAGUES FALLS, NEAR BARING, ME.

This station was established December 4, 1902, by F. E. Pressey. The drainage area at this point is 1,390 square miles. A standard chain gage is attached to the lower guard timber of the Washington County Railroad bridge; length of chain, 24.84 feet. It is referred to bench marks as follows: (1) The downstream corner of bridge seat on

right abutment; elevation, 17.60 feet. (2) Copper bolt in bowlder on right bank about 200 feet downstream from the bridge; elevation, 15.98 feet. Elevations refer to the datum of the gage.

The measurements of flow are made from a car suspended on a steel cable stretched over the river about one-half mile above the bridge. The initial point for soundings is 60 feet from small pine tree near anchorage on right bank. The channel is straight for 100 feet above and 1,000 feet below the cable, and has an unbroken width of about 200 feet at ordinary stages. The banks are high and rocky, and the bed is rocky and permanent. The observed mean velocity at the cable has varied between 5.49 feet per second at gage height 9.70 feet and 1.29 feet per second at gage height 6.53 feet. The measurement at gage height 6.11 feet was made from the bridge to which the gage is attached; mean velocity, 1.41 feet per second. The gage is read twice daily by Simeon Phinney, section foreman on the Washington County Railroad, who resides in Baring, Me.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of St. Croix River at Spragues Falls, near Baring, Me., in 1903 and 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Square feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
March 21	R. M. Connor	1,070	5.50	9.70	5,880
April 20	do	984	5.15	9.30	5,060
April 28	do	751	3.59	8.30	2,700
April 29	do	778	3.84	8.40	2,990
May 18	do	628	2.30	7.20	1,450
May 19	do	658	2.34	7.30	1,540
September 9	F. E. Pressey	609	1.29	6.53	787
September 9[a]	do	609	1.31	6.55	796
October 1	N. C. Grover	418	1.41	6.11	589
1904.					
April 27	F. E. Pressey	990	4.89	9.27	4,840
August 23[a]	do	570	2.39	7.10	1,360

[a] Made at bridge.

Mean daily gage height, in feet, of St. Croix River at Sprague's Falls, near Baring, Me., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	8.0	[a]8.0	8.2	[b]8.0	.....	8.4	8.1	8.0	6.9	7.4	7.3	6.8
2	8.0	8.0	8.2	8.0	11.0	8.4	8.1	7.9	6.9	.....	7.2	6.8
3	8.1	8.0	8.2	.....	10.9	8.3	.....	7.7	6.9	7.3	7.0	6.8
4	8.3	8.0	8.2	8.1	10.0	8.3	8.0	7.6	.....	7.2	7.0	.....
5	8.3	8.0	8.2	8.1	10.0	.....	8.0	7.5	7.0	7.1	6.9	6.9
6	8.3	8.0	.....	8.3	9.8	8.4	7.9	7.5	7.0	7.0	.....	7.2
7	8.3	.....	8.2	8.6	9.7	8.4	7.8	.....	7.0	6.9	6.9	7.3
8	8.3	7.8	[c]8.5	8.8	.....	8.4	8.3	7.3	6.9	6.9	6.9	7.4
9	.....	7.8	8.5	9.4	8.5	8.4	8.3	7.2	6.8	.....	6.9	7.4
10	.....	7.7	8.5	.....	8.6	8.4	.....	7.2	6.8	6.7	6.9	7.4
11	.....	7.7	8.5	12.4	8.7	8.4	8.5	7.2	.....	6.7	6.8	.....
12	8.0	[d]7.7	8.5	12.4	10.1	.....	8.6	7.2	6.7	6.7	6.8	7.9
13	8.0	7.7	.....	12.0	11.7	8.1	8.8	7.2	6.7	6.7	.....	7.9
14	8.0	.....	8.6	11.4	11.9	8.1	8.8	.....	6.7	7.0	6.8	7.9
15	8.0	7.8	8.6	10.9	.....	7.9	8.9	7.2	7.0	7.1	6.8	7.7
16	8.0	7.8	8.6	10.5	11.2	7.9	8.9	7.1	7.1	.....	6.8	7.5
17	7.9	7.8	8.6	.....	10.5	7.9	.....	7.1	7.1	7.0	6.7	7.5
18	7.8	[e]7.8	8.6	9.4	10.5	7.9	8.6	7.1	.....	7.0	6.6	.....
19	7.7	7.8	8.6	9.4	10.4	.....	8.6	7.1	7.0	7.0	6.6	7.2
20	7.7	7.8	.....	9.6	10.2	7.8	8.6	7.1	6.9	7.0	.....	7.0
21	7.8	.....	8.5	9.4	10.1	7.8	8.6	.....	6.8	6.9	6.7	6.7
22	7.9	[f]8.0	8.5	9.4	.....	8.2	8.6	7.2	6.8	6.9	6.8	7.0
23	7.9	8.0	8.4	9.4	9.9	8.2	8.6	7.2	6.8	.....	6.8	7.0
24	.....	8.0	8.4	.....	9.8	8.2	.....	7.1	6.8	7.8	6.9	7.0
25	8.0	8.1	8.4	9.3	9.8	8.2	8.6	7.1	.....	7.7	7.0	.....
26	8.0	8.1	8.4	9.3	9.6	.....	8.6	7.1	7.1	7.5	7.1	6.9
27	[g]8.0	8.1	8.4	9.3	9.6	8.1	8.7	7.1	7.1	7.4	.....	6.9
28	8.0	.....	8.4	9.3	9.5	8.1	8.7	.....	7.0	7.4	7.0	6.9
29	8.0	8.1	8.0	9.3	.....	8.1	8.7	7.0	7.0	7.4	6.9	6.8
30	8.0	.....	8.0	9.4	8.9	8.1	8.7	6.9	7.0	.....	6.8	6.8
31	.....	.....	8.0	.....	8.7	.....	.....	6.9	.....	7.3	.....	6.8

[a] Ice 0.85 foot thick.
[b] River clear of ice.
[c] Ice 1 foot thick.
[d] Ice 1.1 feet thick.
[e] Ice 1.25 feet thick.
[f] Thaw; water running on top of ice.
[g] Water and ice same height; ice 0.4 foot thick; river froze about Jan. 19.

NOTE.—During frozen season gage readings are to surface of water in hole cut in ice.

Rating table for St. Croix River at Spragues Falls, near Baring, Me., from December 4, 1902, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
5.9	525	7.1	1,330	8.3	2,775	9.5	5,450
6.0	655	7.2	1,440	8.4	2,920	9.6	5,750
6.1	585	7.3	1,550	8.5	3,075	9.7	6,055
6.2	620	7.4	1,660	8.6	3,245	9.8	6,360
6.3	660	7.5	1,775	8.7	3,430	10.0	6,970
6.4	710	7.6	1,890	8.8	3,635	10.2	7,580
6.5	770	7.7	2,010	8.9	3,855	10.4	8,190
6.6	840	7.8	2,130	9.0	4,090	10.6	8,800
6.7	925	7.9	2,255	9.1	4,340	10.8	9,410
6.8	1,020	8.0	2,380	9.2	4,605	11.0	10,020
6.9	1,120	8.1	2,510	9.3	4,880	11.5	11,545
7.0	1,225	8.2	2,640	9.4	5,160		

The above table is applicable only for open-channel conditions. It is based upon 11 discharge measurements made during 1903 and 1904. It is well defined between gage heights 6.10 feet and 9.50 feet. The table has been extended beyond these limits. Above gage height 9.60 the rating curve is a tangent, the difference being 305 per tenth.

Estimated monthly discharge of St. Croix River at Spragues Falls, near Baring, Me., for 1904.[a]

[Drainage area, 1,390 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
April	14,290	2,380	6,027	4.34	4.84
May	12,760	3,075	7,026	5.05	5.82
June	2,920	2,130	2,605	1.87	2.09
July	3,855	2,130	3,089	2.22	2.56
August	2,380	1,120	1,495	1.08	1.24
September	1,330	925	1,140	.820	.915
October	2,130	925	1,368	.984	1.13
November	1,550	840	1,102	.793	.885
December	2,255	925	1,418	1.02	1.18

[a] Sunday discharges interpolated.

MACHIAS RIVER DRAINAGE BASIN.

The Machias may be taken as fairly representative of several of the smaller streams of Maine which empty their waters directly into the ocean, and which are commonly referred to as "coastal rivers." Its total drainage basin is 495 square miles, nearly all of which lies in Washington County, Me. Its extreme headwaters lie at an elevation of nearly 500 feet, and are not more than 50 miles from tide water. Wells listed 20 lakes in this basin, aggregating 29.5 square miles in area of water surface. Without important exception these lie, however, in the extreme headwaters. Dams are maintained at several of the outlets of the lakes, and the stored water is used for log driving.

The underlying rock is usually granite. Probably 70 to 80 per cent of the basin is still in forest.

MACHIAS RIVER NEAR WHITNEYVILLE, ME.

This gaging station was established October 17, 1903, by F. E. Pressey, at the bridge of the Washington County Railroad, near Whitneyville. The drainage area at this point is 465 square miles. A standard chain gage is attached to the guard timber on the downstream side of the bridge; length of chain, 25.34 feet. It is referred to the following-described bench marks: (1) Copper bolt in outcropping ledge on upstream side of railroad track and 170 feet from the face of left abutment; elevation, 20.12 feet. (2) Downstream outer corner of bridge seat of right abutment; elevation, 18.05 feet. (3) Marked point on floor beam of bridge at zero end of gage; elevation, 23.89 feet. Elevations refer to datum of the gage. The initial point for soundings is on the left bank at the lower end of the inclined end post of the downstream truss. The velocity is small at low water. Meter measurements may be made by wading at a point 200 feet above the bridge at low stages of the river. The water is confined to one channel at the bridge at all stages; the width is about 130 feet.

A short distance above the station is a dam which stores water for use by the mills in Machias. The gates in this dam are opened and closed each day during low stages of the river. As a result the river fluctuates as much as 0.5 of a foot on the gage. The bed is sandy, but permanent. The gage is read twice daily by George McKenzie, a farmer of Whitneyville.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Machias River near Whitneyville, Me., in 1903 and 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Square feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
October 17	F. E. Pressey	647	0.34	6.63	221
1904.					
April 26	F. E. Pressey	1,030	1.92	9.67	1,970
April 28	do	1,230	2.42	11.19	2,970
May 17	do	1,250	2.94	11.64	3,670
May 20	do	1,360	3.16	12.41	4,300
May 20	do	1,360	3.07	12.38	4,170
May 21	do	1,320	2.88	12.07	3,800
August 22	do	860	1.28	8.54	1,100
August 24	do	730	.74	7.51	540
November 7	do	580	.56	6.40	325

Mean daily gage height, in feet, of Machias River near Whitneyville, Me., for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.[a]	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.[a]
1	7.3	7.9	7.8	9.3	12.4	10.0	7.5	6.0	6.0	7.9	6.2	6.4
2	7.2	7.8	7.8	9.4	11.9	10.0	7.6	5.7	5.8	8.1	6.2	6.4
3	7.2	[b]7.7	[c]8.0	9.9	11.2	10.0	7.8	5.4	6.0	7.6	6.0	6.2
4	7.1	7.7	8.8	9.6	10.1	10.0	7.8	5.2	5.8	7.2	6.4	6.2
5	7.2	7.6	9.4	9.4	9.2	10.0	7.2	5.4	6.2	7.0	6.5	5.8
6	[d]7.2	7.6	9.5	9.6	8.8	9.4	7.0	5.4	6.8	6.8	6.4	5.6
7	7.2	7.7	9.3	10.0	8.3	9.7	6.9	5.6	5.6	6.8	6.5	5.5
8	7.2	7.6	10.4	10.4	8.2	10.3	6.9	6.0	6.7	6.8	6.4	5.4
9	7.2	8.0	12.2	11.4	7.9	9.6	6.8	5.9	6.5	6.9	6.0	5.6
10	7.2	7.6	11.8	12.8	9.2	8.8	7.6	5.2	6.3	6.8	6.2	6.2
11	7.2	[e]7.7	11.0	14.0	10.9	8.2	7.3	5.4	5.0	6.6	6.4	6.3
12	7.3	7.8	10.5	13.3	13.9	8.1	6.8	5.7	5.0	6.1	6.2	6.2
13	7.3	7.7	10.4	12.8	15.6	7.9	7.0	5.8	5.6	6.8	6.6	6.2
14	7.6	7.7	9.6	12.4	14.0	7.6	7.2	5.9	6.2	7.6	7.0	[f]6.2
15	7.7	7.6	9.2	11.6	11.4	7.6	7.2	6.1	7.9	7.0	7.4	6.2
16	7.7	7.6	9.0	10.6	10.6	7.5	7.0	6.0	10.8	7.1	7.4	6.2
17	7.7	7.5	8.7	10.1	11.9	7.4	7.4	5.8	9.4	7.0	6.6	[g]6.4
18	7.6	[h]7.4	8.2	9.8	12.9	7.2	7.2	6.2	8.2	6.6	7.0	6.2
19	7.6	7.3	8.0	9.7	13.0	7.4	6.3	6.2	7.5	6.4	6.4	6.1
20	7.6	7.2	8.0	9.8	12.4	7.2	6.3	5.7	6.9	6.1	6.4	[i]6.1
21	7.6	7.2	8.2	9.5	12.0	7.2	6.3	8.1	6.7	6.4	6.4	6.1
22	7.6	7.4	8.1	[j]9.2	11.7	7.2	6.0	8.6	6.6	8.0	6.4	[k]6.3
23	7.5	8.0	8.3	9.2	11.4	7.2	5.9	8.0	6.6	9.3	6.7	6.2
24	7.5	8.4	8.8	9.3	10.6	7.2	6.6	7.5	6.4	8.5	6.8	6.1
25	7.5	[l]8.6	9.2	9.3	9.6	7.2	6.6	7.0	7.2	7.6	7.3	6.1
26	7.5	8.6	9.7	9.6	9.4	7.3	6.2	6.2	8.0	7.2	7.4	6.0
27	7.6	8.4	11.0	10.6	9.2	7.2	6.2	5.2	7.8	7.2	7.0	6.0
28	7.5	8.2	11.0	11.2	9.5	7.0	6.0	5.8	7.0	7.0	6.6	6.2
29	7.7	7.9	10.4	11.4	9.8	6.8	5.8	5.8	7.0	6.8	6.2	6.4
30	7.7	.....	9.7	12.4	9.9	6.8	5.7	6.2	7.1	6.8	6.3	6.2
31	7.8	.....	9.3	.....	9.9	.....	6.0	6.2	.....	6.5	.....	[m]6.3

[a] Ice January 1 to March 21 and December 9–31. No estimate.
[b] Ice 1.35 feet thick.
[c] Ice 1.25 feet thick.
[d] Ice 0.65 foot thick.
[e] Ice 1.5 feet thick.
[f] Gage reading to surface of ice=6.3; ice 0.7 foot thick.
[g] Gage reading is to surface of ice; ice 0.8 foot thick.
[h] Ice 1.65 feet thick.
[i] Ice 0.8 foot thick.
[j] River clear of ice.
[k] Gage reading is to surface of ice; ice 1.0 foot thick.
[l] Ice 1.4 feet thick.
[m] Gage reading is to surface of ice; ice 1.1 feet thick.

NOTE.—Unless otherwise noted, gage heights during frozen season are to surface of water in hole cut in ice.

Rating table for Machias River near Whitneyville, Me., from October 17, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet*	*Second-feet.*
6.6	258	7.4	500	8.4	1,000	10.0	2,130
6.7	283	7.5	542	8.6	1,120	10.5	2,545
6.8	309	7.6	587	8.8	1,250	11.0	2,980
6.9	336	7.7	634	9.0	1,380	11.5	3,430
7.0	365	7.8	682	9.2	1,520	12.0	3,900
7.1	395	7.9	730	9.4	1,660	12.5	4,375
7.2	427	8.0	780	9.6	1,810	13.0	4,860
7.3	462	8.2	890	9.8	1,970		

The above table is applicable only for open-channel conditions. It is based upon 11 discharge measurements made during 1903 and 1904. It is well defined between gage heights 7.5 feet and 12.5 feet. The table has been extended beyond these limits, and is very uncertain below 7 feet.

Estimated monthly discharge of Machias River near Whitneyville, Me., for 1903 and 1904.

[Drainage area, 465 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1903.					
October 18–31	1,060	258	562	1.21	.630
November	1,185	336	652	1.40	1.56
December	1,217	445	703	1.51	1.74
1904.					
March 22–31	2,980	835	1,834	3.94	1.47
April	5,860	1,520	2,681	5.77	6.44
May	7,570	730	2,979	6.41	7.39
June	2,375	309	989	2.13	2.38
July	682	104	334	.718	.828
August	1,120	54	216	.465	.536
September	2,800	41	438	.942	1.05
October	1,590	159	448	.963	1.11
November	500	144	265	.570	.636
December 1–8	213	71	142	.305	.091

PENOBSCOT RIVER DRAINAGE BASIN.

This basin, which has a total area of about 8,500 square miles, lies wholly in Maine. It extends from the Atlantic Ocean on the south to the basin of the St. John on the north, a distance of 160 miles; and from the New Brunswick boundary on the east to the Quebec boundary on the west, a distance of 115 miles. The general elevation of the basin is lower than that of the drainage basins to the west. The headwaters of the main river lie in the mountainous region on the boundary of Quebec at an elevation of nearly 2,000 feet. The slopes of the upper tributaries are generally steep. Chesuncook Lake lies near the center of the basin at an elevation of 930 feet. From this point to tidewater, the distance along the river is about 121 miles, indicating an average slope of 7.7 feet to the mile. This is concentrated at intervals by ledges where water power has been or may be developed. The water from some 800 square miles of the basin is discharged into the main river below its lowest available water power at Bangor.

Taken as a whole, the basin is rather uniform in its topographic features. Hills and low mountains stretch from near the sea to above Bangor; farther north is an undulating plain, while to the west the surface becomes more broken and is greatly diversified by hills, detached peaks, lakes, ponds, and swamps. At the south the basin merges into that of the Kennebec, and at the north into that of the Alleguash, terminating on the northwest, at the boundaries of the State, in a region of highland intermingled with swamps and lagoons. The whole northern basin of the main river and its tributaries is in forest. Original growth covers a large portion of this area, and in general, wherever cuttings have been made, a dense second growth has sprung up. Extensive areas in the southern basin have been cleared and converted into farms. Probably 70 to 80 per cent of the whole basin above Bangor is in forest. Throughout the upper portion of the basin slate is the principal outcropping rock, being succeeded to the east and south by schists, gneiss, and granite. The soil is mainly clay, gravel, and loam.

The drainage area of the river and its chief tributaries are given in the following table.

Drainage areas of Penobscot River and principal tributaries. [a]

River.	Locality.	Drainage area.
		Square miles.
Penobscot	Opposite northwest extremity of Moosehead Lake, township of Seboomook, immediately below mouth of Nulhedus Creek.	510
Do	Entrance into Chesuncook Lake	850
Do	Outlet of Chesuncook Lake	1,450
Do	Millinocket, outlet of Twin Lakes	1,880
Do	Immediately below mouth of East Branch of Penobscot. [a]	3,260
Do	Immediately below mouth of Mattawamkeag. [a]	4,940
Do	West Enfield, immediately below mouth of Piscataquis. [a]	6,630
Do	Sunk Haze Rips [a]	7,260
Do	Old Town, above mouth of Pushaw River [a]	7,340
Do	Bangor, above mouth of Kenduskeag River [a]	7,720
Do	Mouth [a]	8,550
Cauquomogomoc	Entrance into Chesuncook Lake	230
East Branch of Penobscot	Grindstone [a]	1,130
Do	Mouth [a]	1,160
Mattawamkeag	Immediately below outlet of Baskahegan Lake.	190
Do	Mouth	1,510
Piscataquis	Low's bridge	280
Do	Dover	330
Do	Mouth	1,500
Passadumkeag	....do	400
Cold Stream	....do	37
Do	Enfield post-office	26
Phillips Lake outlets:		
Northern outlet at junction with.	Phillips Lake	11.5
Northern outlet	East Holden	12.3
Phillips Lake area		1.4

[a] Includes Chamberlain Lake basin (270 square miles). See description of St. John River drainage basin.

The United States Geological Survey now maintains gaging stations at the following places in the Penobscot basin: On the Penobscot at West Enfield; East Branch of the Penobscot at Grindstone; Mattawamkeag at Mattawamkeag; Piscataquis near Foxcroft; Cold Stream at Enfield; Phillips Lake and its outlets in Holden and Dedham.

The discharge of the Penobscot is also obtained at Millinocket from data furnished by private parties.

PENOBSCOT RIVER AT MILLINOCKET, ME.

The discharge of Penobscot River at Millinocket has been computed and the data furnished by H. S. Ferguson, engineer for the Great Northern Paper Company. These results were obtained by considering the flow through the wheels, the flow over the dam, and such quantities of water as are used from time to time by the log sluice, filters, etc. The wheels were rated at Holyoke, Mass., before being placed in position. As the head under which they work, averaging about 110 feet, is much greater than the head under which they were tested, numerous tube float measurements of flow in the canal leading to the mill have been made by Mr. Ferguson, in order to determine just how much water the mill used under different conditions of gate openings. In addition to this, during 1904 a series of current-meter measurements were made by the United States Geological Survey to check results as obtained by the floats, and to enable a suitable coefficient to be obtained for use with the float measurements. It is believed by means of these various checks upon the measurements that a very good estimate has been made for the flow through the wheels. The dam, known as Quakish Lake dam, is of concrete, resting on rock, and does not leak. The flow over it was computed by use of the formula, $Q = c\ b\ H^{\frac{3}{2}}$, in which c is a variable coefficient obtained (1) from the results of weir measurements made by Mr. Ferguson on 10-foot portion of the dam, and (2) from a study of the results of experiments made by George W. Rafter at the Cornell testing flume.

When the flow of the river is less than 2,500 second-feet all of the water is generally used through the mill; at higher stages the excess is wasted over the dam. The flow over the flashboards, which are used whenever possible, is computed by use of the formula $Q = 3.33\ b\ H^{\frac{3}{2}}$. The area of the drainage basin at Millinockett is 1,880 square miles. Several dams, which have been constructed at points in the basin above this point, store water on a surface of practically 80 square miles. This water is used for log driving and for manufacturing purposes. Quakish Lake dam is at elevation 456.3 feet above mean sea level, as determined by the Penobscot River survey of 1904.

Mean daily discharge, in second-feet, of Penobscot River at Millinocket, Me., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	237	413	403	315	(a)	4,705	4,088	2,366	2,027	3,005	2,255	(a)
2	141	360	407	284	2,266	4,566	4,894	4,977	2,389	(a)	2,261	2,261
3	159	410	416	560	2,294	4,247	4,490	4,988	2,020	2,186	2,251	2,292
4	417	401	389	338	2,150	4,151	4,520	4,982	2,653	(a)	2,326	2,204
5	405	409	414	221	2,297	4,844	4,247	4,958	2,420	2,298	2,336	2,285
6	421	408	109	582	2,332	4,746	4,309	2,424	2,014	2,026	2,298	2,250
7	436	200	368	1,013	2,326	5,345	4,330	2,077	2,018	2,313	2,271	2,002
8	392	436	404	681	2,116	4,900	2,448	2,308	2,026	2,363	2,347	2,359
9	398	415	392	702	(a)	4,358	4,535	4,913	1,996	2,350	2,367	2,366
10	385	448	397	436	2,235	4,353	2,031	4,936	2,024	2,437	2,331	(a)
11	430	423	391	639	2,306	4,209	3,386	4,936	2,390	2,077	2,318	(a)
12	393	438	492	1,019	2,332	4,197	3,076	4,939	2,331	2,062	2,355	(a)
13	345	430	467	995	2,315	4,780	3,068	4,924	2,041	2,341	2,394	(a)
14	244	198	737	1,067	2,384	3,848	2,219	4,659	2,400	2,048	2,310	(a)
15	362	411	724	973	5,100	3,198	2,010	4,789	2,019	2,005	(a)	2,200
16	438	433	828	859	5,010	2,433	2,007	4,937	2,023	2,311	(a)	2,000
17	216	434	799	1,095	10,255	2,415	3,093	4,959	(a)	2,015	(a)	2,250
18	376	434	421	1,056	11,314	2,417	2,031	4,921	2,162	2,026	(a)	2,005
19	332	433	793	1,094	11,682	2,277	2,392	2,347	2,339	2,423	(a)	2,010
20	205	403	488	1,112	11,678	2,418	2,906	2,014	2,025	2,042	(a)	(a)
21	428	188	788	1,108	10,671	2,434	4,097	2,027	2,018	2,059	2,293	(a)
22	414	200	814	1,473	7,043	2,454	2,420	2,178	2,327	2,049	2,291	(a)
23	297	200	462	1,457	7,324	2,433	2,037	2,008	(a)	2,015	2,289	(a)
24	149	275	470	1,072	9,276	2,424	3,658	2,378	(a)	2,310	2,255	2,003
25	450	426	453	1,473	8,645	3,125	2,005	2,017	2,212	2,403	(a)	2,000
26	416	415	818	1,463	5,266	5,028	2,019	2,002	2,005	2,055	(a)	2,549
27	431	404	615	1,469	4,737	4,757	3,663	2,000	2,002	2,067	2,555	2,008
28	214	189	823	1,807	3,710	4,171	(a)	2,312	2,023	2,077	2,302	2,012
29	238	368	408	1,802	3,831	3,106	(a)	2,022	2,003	2,027	2,008	(a)
30	249	.....	444	1,805	5,142	2,488	3,703	2,035	2,010	(a)	2,010	2,287
31	150	.....	420	.....	5,448	.....	2,005	2,119	.....	(a)	.....	2,002

a Owing to incompleteness of records discharge can not be computed.

PENOBSCOT RIVER AT WEST ENFIELD, ME.

This station was established by N. C. Grover on November 5, 1901, and in previous reports has been designated as being at Montague, Me. In 1904 the name of this village was changed to West Enfield. It is located at the steel highway bridge, about 1,000 feet below the mouth of Piscataquis River. The drainage area at this point is 6,630 square miles, including the area of the drainage basin of Chamberlain Lake (270 square miles), which flows into the Penobscot part of the year only.[a] The measurements are made from the bridge. A standard chain gage is fastened to the steel webbing on the upstream side of the bridge; length of chain, 34.49 feet. It is referred to bench marks as follows: (1) The top of the northwest corner of first course below bridge seat, easterly abutment; elevation, 25.78 feet. (2) Copper bolt in outcropping ledge under bridge, near east abutment; elevation, 6.71 feet. (3) Marked point on bottom chord of bridge, under gage;

a See description of St. John River drainage basin.

elevation, 29.52 feet. All elevations are above gage datum and gage datum is at an elevation of 125.38 feet above mean sea level, as determined by the Penobscot River survey of 1904. The initial point for soundings is on the easterly abutment, at the extreme end of the inclined end post on downstream side of bridge. The channel is straight for 1,000 feet above and 3,000 feet below the station, is about 870 feet wide, and is broken by four piers. The banks are high and rocky, and the bed permanent and rocky, with some gravel. The observed mean velocity has varied from 5.05 feet per second at gage height 12.90 to 1.08 feet per second at gage height 1.54. Water power is used on both the Penobscot and Piscataquis rivers within a mile above the station. Fluctuations at the gage of 0.2 or 0.3 of a foot during low water are caused by changes in gate openings at the mills above. The gage is read twice daily by A. H. Hanson, a merchant in West Enfield.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Penobscot River at West Enfield, Me., in 1901–1904.

Date	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
1901.		*Square feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
November 5	F. E. Pressey	2,200	1.38	2.00	3,030
1902.					
March 28	F. E. Pressey	11,380	5.05	12.80	57,400
April 8	do	9,520	4.62	10.90	43,900
July 15	N. C. Grover	4,650	2.42	5.10	11,300
August 28	F. E. Pressey	3,590	2.11	3.80	7,580
September 15	do	3,680	2.11	3.90	7,770
October 11	R. M. Connor	3,640	2.05	3.75	7,450
1903.					
May 14	F. Collins	6,140	2.86	6.65	17,600
May 25	E. C. Murphy	3,960	2.12	4.10	8,410
June 11	N. C. Grover	3,140	1.88	3.21	5,910
August 7	F. E. Pressey	3,210	1.91	3.22	6,140
October 15	N. C. Grover	1,920	1.08	1.54	2,070
October 23	F. E. Pressey	1,970	1.20	1.58	2,370
1904.					
April 26	N. C. Grover	8,770	3.67	9.70	32,200
May 18	F. E. Pressey	10,900	4.51	12.06	49,200
May 27	do	7,210	3.07	8.01	22,100
June 14	N. C. Grover	5,380	2.49	5.82	13,400
October 17	University of Maine students.[a]	4,000	2.02	4.23	8,100
October 20	do	3,800	1.89	3.90	7,200
October 25	do	5,000	2.16	5.25	10,800
October 31	do	4,450	2.16	4.73	9,600

[a] Under direction of Prof. H. S. Boardman.

Mean daily gage height, in feet, of Penobscot River at West Enfield, Me., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	[a] 2.80	.....	.....	12.30	7.20	4.25	4.05	2.80	7.05	4.65	3.20
2	.....	.....	.....	.....	12.00	6.80	5.15	3.70	2.70	6.90	4.45	3.15
3	.....	.....	.....	.....	11.60	7.75	5.90	4.30	2.80	6.30	4.45	3.40
4	[b] 3.50	.....	.....	6.15	11.20	7.15	6.20	4.70	2.80	5.65	4.30	3.45
5	.....	.....	.....	6.25	11.15	6.50	5.75	4.55	3.55	5.30	4.20	3.50
6	.....	.....	.....	6.50	10.65	6.90	5.45	4.40	3.70	5.05	4.10	3.50
7	.....	.....	[c] 2.70	6.75	10.10	7.20	5.10	4.15	3.65	4.75	4.15	3.45
8	.....	[d] 2.60	.....	7.60	9.10	7.55	4.70	4.05	3.35	4.65	4.50	3.70
9	.....	.....	.....	[e] 8.70	8.45	6.95	4.45	4.15	3.20	4.55	4.40	3.85
10	.....	.....	.....	9.65	8.45	6.60	4.35	4.10	3.20	4.35	4.30	4.25
11	[f] 3.30	.....	.....	10.75	10.10	6.50	5.00	4.20	3.10	4.20	4.20	4.25
12	.....	.....	.....	11.20	11.60	6.40	4.35	4.30	3.00	4.15	4.10	4.15
13	.....	.....	.....	11.00	11.80	6.20	4.25	4.20	3.05	4.10	4.05	(g)
14	.....	.....	[h] 4.90	10.40	10.90	5.90	4.50	4.10	2.75	4.20	4.05	.....
15	.....	[i] 2.40	.....	9.85	10.25	5.50	4.75	4.00	3.05	4.20	3.95	.....
16	.....	.....	.....	9.05	10.70	5.05	4.25	4.10	4.35	4.15	3.70	.....
17	.....	.....	.....	8.30	11.85	4.90	3.85	3.95	4.80	4.15	3.60	.....
18	[a] 3.40	.....	.....	7.90	11.90	5.20	4.50	3.75	4.50	4.10	3.50	.....
19	.....	.....	.....	7.80	11.55	5.85	3.80	3.50	4.15	4.05	3.60	[j] 4.30
20	.....	.....	.....	7.90	11.80	5.50	3.90	3.15	4.25	4.00	3.55	.....
21	.....	.....	[k] 4.70	7.80	12.00	5.15	4.05	3.45	4.10	3.90	3.55	.....
22	.....	[l] 2.60	.....	7.75	11.20	5.00	4.20	3.85	4.20	4.55	3.90	.....
23	.....	.....	.....	7.90	10.60	4.95	3.50	3.55	4.10	5.80	3.85	.....
24	.....	.....	.....	8.20	10.45	4.75	3.40	3.40	4.15	5.65	3.85	.....
25	[a] 3.20	.....	.....	8.60	9.90	4.55	3.65	3.30	4.75	5.25	3.80	.....
26	.....	.....	.....	9.85	8.80	4.65	3.35	3.15	5.30	5.05	3.70	[m] 4.30
27	.....	.....	.....	10.15	8.05	4.90	3.80	2.95	5.10	5.45	3.65	.....
28	.....	.....	[a] 6.00	10.25	7.95	4.75	4.15	2.70	4.65	5.65	3.40	.....
29	.....	[n] 2.40	.....	10.35	7.60	4.15	3.45	2.80	4.85	5.45	3.30	.....
30	.....	.....	.....	11.10	7.30	3.75	3.25	2.80	5.45	5.10	3.20	.....
31	.....	.....	.....	.....	7.35	.....	3.30	2.75	.....	4.70	.....	.....

NOTE.—During frozen season readings are to surface of water in hole cut in ice.

[a] Ice 1.15 feet thick.
[b] Ice 1 foot thick.
[c] Ice 1.6 feet thick.
[d] Ice 1.25 feet thick.
[e] Clear of ice.
[f] Ice 1.1 feet thick.
[g] Frozen over.
[h] Ice 1.5 feet thick.
[i] Ice 1.35 feet thick.
[j] Ice 0.65 foot thick.
[k] Ice 1.4 feet thick.
[l] Ice 1.5 feet thick.
[m] Ice 0.75 foot thick.
[n] Ice 1.65 feet thick.

Rating table for Penobscot River at West Enfield, Me., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.7	4,420	4.1	7,740	6.0	13,580	8.8	26,620
2.8	4,620	4.2	8,020	6.2	14,270	9.0	27,860
2.9	4,830	4.3	8,310	6.4	14,980	9.2	29,100
3.0	5,050	4.4	8,600	6.6	15,720	9.4	30,360
3.1	5,270	4.5	8,900	6.8	16,500	9.6	31,640
3.2	5,500	4.6	9,200	7.0	17,300	9.8	32,960
3.3	5,730	4.7	9,500	7.2	18,140	10.0	34,300
3.4	5,960	4.8	9,800	7.4	19,020	10.5	37,760
3.5	6,200	4.9	10,100	7.6	19,940	11.0	41,320
3.6	6,440	5.0	10,400	7.8	20,920	11.5	45,000
3.7	6,690	5.2	11,000	8.0	21,980	12.0	48,820
3.8	6,940	5.4	11,620	8.2	23,080	12.5	52,780
3.9	7,200	5.6	12,260	8.4	24,220	13.0	56,920
4.0	7,470	5.8	12,910	8.6	25,040		

The above table is applicable only for open-channel conditions. It is based upon 8 discharge measurements made during 1904. It is well defined between gage heights 3.90 feet and 12.10 feet. The table has been extended beyond these limits, and is uncertain below gage height 3.9 feet. The discharge as given by the 1904 curve is several per cent smaller than the 1903 curve, owing to obstructions in the river below the station.

Estimated monthly discharge of Penobscot River at West Enfield, Me., for 1904.

[Drainage area, 6,630 square miles.][a]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
April 9–30	42,780	20,670	30,110	4.54	3.71
May	51,180	18,580	36,880	5.56	6.41
June	20,670	6,815	13,200	1.99	2.22
July	14,270	5,615	8,540	1.29	1.49
August	9,500	4,520	6,889	1.04	1.20
September	11,780	4,420	7,239	1.09	1.22
October	17,510	7,200	10,240	1.54	1.78
November	9,350	5,500	7,335	1.11	1.24
December 1–12	8,165	5,385	6,615	.998	.445

[a] Includes Chamberlain Lake drainage. See description of St. John River drainage basin.

PENOBSCOT RIVER (EAST BRANCH) AT GRINDSTONE, ME.

This station was established October 23, 1902, by F. E. Pressey. It is located at the Bangor and Aroostock Railroad bridge, one-half mile south of the railway station. The measurements are made from the

railway bridge. The drainage area at this point is 1,130 square miles, including the Chamberlain Lake basin (270 square miles). The initial point for soundings is on the left bank, at the lower end of the inclined end post. The gage is of the standard chain type; length of chain, 31.99 feet. The scale board is nailed to the guard timber on the upstream side of the bridge. It is referred to the following-described bench marks: (1) Southwest corner of bridge seat on east abutment; elevation, 26.32 feet. (2) Copper bolt in ledge under north end of bridge; elevation, 8.78 feet. (3) Marked point on center stringer, near gage; elevation, 29.78 feet. All elevations are above gage datum. The channel both above and below this station is straight. The flow is moderately rapid at medium and high stages of the river. Observed mean velocities range from 2.27 feet per second at gage height 8.10 feet, to 0.18 foot per second at gage height 4.32 feet. Fluctuations in stage are usually slow, as no water power is used on the river above the station. Dams are maintained at the outlets of several of the lakes and ponds near the source of the river, and the impounded water is used for log driving. The bed is rocky and permanent; the stream is confined to the channel by the abutments of the bridge and has a width of about 275 feet, broken by one pier. Practically all land areas in this basin are in forest. The gage is read twice daily by Harry Stinson.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Penobscot River (East Branch) at Grindstone, Me., 1902–1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1902.		*Feet.*	*Square feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
October 23	F. E. Pressey	226	1,410	0.50	5.15	706
November 26	do	225	1,490	.62	5.41	921
1903.						
April 9	N. C. Grover	262	2,170	2.15	7.85	4,670
April 14	do	266	2,270	2.36	8.10	5,350
April 22	F. E. Pressey	258	1,930	1.67	7.20	3,230
May 23	C. N. McCulloch	245	1,830	1.41	6.64	2,580
September 9	N. C. Grover	228	1,270	.17	4.32	223
September 26	do	236	1,510	.54	5.36	824
October 28 [a]	F. E. Pressey	230	648	.73	4.58	474
1904.						
April 29	N. C. Grover	270	2,450	3.34	9.13	8,180
October 24	F. E. Pressey	247	1,740	1.28	6.32	2,230

[a] Measurement made from boat.

Mean daily gage height, in feet, of Penobscot River (East Branch) at Grindstone, Me., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	.....	.....	10.30	8.70	6.10	7.00	4.60	7.15	5.60	.....
2	.....	.....	.....	.....	10.80	8.60	6.30	6.80	4.60	7.30	5.60	.....
3	4.20	.....	.....	.....	10.25	8.20	6.60	6.60	4.70	7.30	5.60	[a]4.30
4	.....	.....	.....	[b]4.80	9.60	7.25	6.80	6.60	5.40	6.90	5.30	.....
5	.....	.....	.....	.....	9.60	7.35	6.80	6.70	5.60	6.55	5.30	.....
6	.....	.....	[c]3.40	.....	9.40	8.20	6.40	6.80	5.40	6.30	5.30	.....
7	.....	[d]3.30	.....	.....	8.40	7.90	6.20	6.95	5.05	6.10	5.30	.....
8	.....	.....	.....	.....	7.65	7.90	6.20	7.00	5.00	6.05	5.30	.....
9	.....	.....	.....	.....	7.30	8.05	6.20	7.00	5.00	5.90	5.30	.....
10	[e]3.50	.....	.....	6.50	7.75	8.20	6.20	7.00	4.80	5.80	5.30	[f]4.10
11	.....	.....	.....	.....	8.30	8.20	6.20	7.00	4.70	5.80	5.20	.....
12	.....	.....	.....	.....	9.05	8.20	6.20	6.80	4.70	5.85	5.20	.....
13	.....	.....	[g]3.40	.....	9.50	8.05	6.20	6.80	4.70	5.60	5.30	.....
14	.....	[d]3.30	.....	.....	8.65	8.05	6.05	5.40	4.70	5.60	5.30	.....
15	.....	.....	.....	.....	8.60	6.30	5.65	5.80	5.10	5.60	5.20	.....
16	.....	.....	.....	.....	7.30	6.40	5.60	5.80	6.20	5.60	5.30	.....
17	[b]3.50	.....	.....	6.50	8.70	6.50	6.10	5.55	5.25	5.60	5.30	.....
18	.....	.....	.....	6.50	8.15	6.60	6.40	5.45	5.60	5.50	5.30	[e]8.00
19	.....	.....	.....	6.50	8.40	6.15	6.55	5.25	5.65	5.50	5.30	.....
20	.....	.....	[h]3.60	6.50	8.75	5.30	6.60	5.20	5.70	5.40	5.30	.....
21	.....	[d]3.30	.....	6.70	9.00	5.50	6.80	5.50	5.55	5.40	5.30	.....
22	.....	.....	.....	7.00	7.65	5.40	6.80	5.30	5.35	6.90	5.30	.....
23	.....	.....	.....	7.20	7.95	5.10	6.95	5.30	5.30	7.15	5.30	.....
24	[b]3.50	.....	.....	7.20	7.90	5.10	7.20	5.40	5.30	6.35	5.30	.....
25	.....	.....	.....	7.75	7.45	5.10	7.20	5.20	5.80	6.30	5.30	[i]8.00
26	.....	.....	.....	8.30	7.20	5.20	7.20	5.20	6.05	6.20	[j]5.30	.....
27	.....	.....	[k]4.40	9.00	7.90	5.20	7.20	5.20	6.10	6.10	.....	.....
28	.....	[k]3.20	.....	9.20	8.70	5.20	7.20	4.90	6.10	6.00	.....	.....
29	.....	.....	.....	9.20	8.90	5.20	7.20	4.85	6.55	6.00	[a]5.30	.....
30	.....	.....	.....	9.90	8.70	5.90	7.20	4.70	6.90	5.75	.....	.....
31	[b]3.50	.....	.....	.....	8.70	.....	7.10	4.60	.....	5.60	.....	[l]3.80

[a] Ice 0.85 feet thick.
[b] Ice 1.35 feet thick.
[c] Ice 2.15 feet thick.
[d] Ice 1.7 feet thick.
[e] Ice 1.15 feet thick.
[f] Ice 1 foot thick.
[g] Ice 2.1 feet thick.
[h] Ice 2 feet thick.
[i] Ice 1.4 feet thick. Gage height to top of ice=6.6 feet.
[j] River frozen November 26.
[k] Ice 1.85 feet thick.
[l] Ice 1.6 feet thick. Gage height to top of ice=4.7 feet.

NOTE.—During frozen season gage readings are to surface of water in hole cut in ice.

Rating table of Penobscot River (East Branch) at Grindstone, Me., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.7	190	4.8	480	6.2	1,755	8.2	5,580
3.75	196	4.9	534	6.3	1,895	8.4	6,090
3.8	202	5.0	593	6.4	2,040	8.6	6,630
3.85	209	5.1	660	6.5	2,190	8.8	7,190
3.9	216	5.2	735	6.6	2,350	9.0	7,770
3.95	224	5.3	815	6.7	2,510	9.2	8,350
4.0	233	5.4	900	6.8	2,675	9.4	8,940
4.1	252	5.5	990	6.9	2,845	9.6	9,540
4.2	273	5.6	1,085	7.0	3,020	9.8	10,140
4.3	296	5.7	1,185	7.2	3,390	10.0	10,750
4.4	323	5.8	1,285	7.4	3,790	10.2	11,370
4.5	356	5.9	1,395	7.6	4,205	10.4	11,990
4.6	393	6.0	1,505	7.8	4,640	10.6	12,610
4.7	434	6.1	1,625	8.0	5,100	10.8	13,230

The above table is applicable only for open-channel conditions. It is based upon 11 discharge measurements made during 1902 to 1904, inclusive. It is well defined between gage heights 4.5 feet and 8 feet. Above gage height 8 feet the curve is somewhat uncertain. The table has been extended beyond these limits.

Estimated monthly discharge of Penobscot River (East Branch) at Grindstone, Me., for 1904.

[Drainage area, 1,130 square miles.] [a]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
April 17–30	10,440	2,190	4,738	4.19	2.18
May	13,230	3,390	6,799	6.02	6.94
June	6,910	660	3,074	2.72	3.03
July	3,390	1,085	2,349	2.08	2.40
August	3,020	393	1,629	1.44	1.66
September	2,845	393	982	.869	.970
October	3,590	900	1,739	1.54	1.78
November 1–25	1,085	735	841	.744	.692

[a] Drainage area includes Chamberlain Lake drainage basin of 270 square miles. See description of St. John River drainage basin.

MATTAWAMKEAG RIVER AT MATTAWAMKEAG, ME.

This station was established August 26, 1902, by F. E. Pressey. It is located at the Maine Central Railroad bridge in the village of Mattawamkeag. The area of the drainage basin at this point is 1,510 square miles. The initial point for soundings is on the south abutment at the lower end of the inclined end post of the downstream truss. The gage is of the standard chain type; length of chain, 33.40 feet. The scale board is nailed to the guard timber of the lower side of the bridge. It is referred to bench marks, as follows: (1) Southwest corner of bridge seat of north abutment; elevation, 26.87 feet. (2) Copper bolt in bowlder north of bridge and west of railroad; elevation, 19.01 feet. (3) Marked point on stringer near gage; elevation, 31.42 feet. All elevations are above gage datum, and gage datum is at elevation 185.93 feet above mean sea level, as determined by the Penobscot River survey of 1904. The channel both above and below this station is straight, and has a width of about 400 feet at ordinary stages, broken by two piers. The bed of the stream is rocky and permanent. The water is confined to the channel by the abutments of the bridge. The observed mean velocities at this station have been between 4.11 feet per second at gage height 9.15 feet and 0.90 of a foot per second at gage height 2.75 feet. Low-water measurements are made by wading at a point about 1 mile above the station, where the velocities are greater than at the bridge and the bed is gravelly. The bridge is slightly oblique to the thread of the stream.

Dams are maintained at the outlets of several of the lakes and ponds in this basin, and the stored water is used for driving logs. Probably 90 per cent of the land surface is in forest. The gage is read twice daily by W. T. Mincher.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Mattawamkeag River at Mattawamkeag, Me., 1902–1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
1902.		*Square feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
July 31	F. E. Pressey	550	2.13	4.40	1,170
August 27	do	685	2.34	4.70	1,600
September 16	do	815	2.06	5.00	1,680
November 8	do	1,160	2.63	5.89	3,050
1903.					
April 4	F. E. Pressey	2,380	4.11	9.15	9,780
April 25	do	1,560	3.47	7.15	5,410
May 18	do	540	2.33	4.58	1,260
May 25	C. N. McCulloch	530	2.09	4.45	1,110
June 11	F. E. Pressey	355	2.09	4.02	742
August 8	do	310	1.80	3.87	558
September 11	N. C. Grover	220	1.55	3.39	340
October 14	do	135	.90	2.75	121
October 23[a]	F. E. Pressey	204	1.47	3.32	300
1904.					
April 15	F. E. Pressey	2,690	4.68	9.85	12,600
April 27	N. C. Grover	2,510	4.55	9.50	11,400
October 20	F. E. Pressey	727	2.42	5.07	1,760

[a] Measurement made by wading.

Mean daily gage height, in feet, of Mattawamkeag River at Mattawamkeag, Me., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1					10.70	6.40	4.50	3.75	3.50	6.10	5.40	5.20
2					11.00	6.30	4.50	3.50	3.40	6.45	5.30	5.10
3	[a] 4.60				11.10	6.20	4.75	3.65	3.45	6.60	5.20	5.00
4					11.00	6.20	4.90	3.70	3.60	6.45	4.95	5.10
5					10.75	6.25	4.90	3.70	3.75	6.25	4.85	5.20
6			[b] 5.00		10.40	6.50	4.90	3.70	4.10	6.05	5.15	5.30
7		[b] 4.20			10.10	6.95	4.90	3.70	4.40	5.85	5.15	5.50
8				[c] 8.20	9.95	7.05	4.85	3.55	4.30	5.65	5.10	5.80
9				7.60	9.45	6.80	4.70	3.40	4.20	5.45	5.10	5.80
10	[d] 4.40			8.20	9.40	6.70	4.70	3.55	4.05	5.30	5.05	5.70
11				9.00	9.15	6.60	4.30	3.70	4.00	5.30	4.90	5.70
12				9.75	9.65	6.50	4.20	3.80	3.90	5.20	4.80	5.70
13			[b] 6.30	9.95	10.85	6.20	4.30	3.80	3.90	5.10	4.80	5.70
14		[b] 4.20		10.05	11.40	6.10	4.30	3.80	3.80	5.25	4.75	5.60
15				9.90	11.70	6.05	4.40	3.75	4.25	5.40	4.65	5.50
16				9.65	11.55	6.00	4.50	3.55	4.55	5.40	4.40	5.40

[a] Ice 1.2 feet thick. [b] Ice 1.7 feet thick. [c] River clear of ice. [d] Ice 1.6 feet thick.

Mean daily gage height, in feet, of Mattawamkeag River at Mattawamkeag, Me., for 1904—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
17	[a] 4.10	.....	.....	9.50	11.30	6.00	4.45	3.60	4.90	5.30	4.40	5.30
18	.....	.....	.....	9.10	10.75	6.00	4.35	3.80	5.05	5.20	4.55	5.20
19	.....	.....	.....	8.90	9.65	6.00	4.10	3.90	5.00	5.20	4.80	5.10
20	.....	.....	[a] 6.30	8.80	9.35	5.85	4.20	3.90	5.10	5.10	5.10	5.00
21	.....	[a] 4.30	.....	8.70	9.35	5.45	4.10	4.00	5.20	5.00	4.80	[b]
22	.....	.....	.....	8.70	8.75	5.15	4.05	4.00	5.10	5.15	4.70	.....
23	.....	.....	.....	8.70	8.60	4.95	4.00	4.00	5.20	5.45	4.75	.....
24	[a] 4.00	.....	.....	8.75	8.55	4.80	3.90	4.00	5.20	5.50	5.00	.....
25	.....	.....	.....	9.05	8.35	4.65	3.85	4.00	5.35	5.60	4.95	.....
26	.....	.....	.....	9.35	7.80	4.45	3.60	4.00	5.65	5.75	5.15	[c] 4.30
27	.....	.....	[d] 6.30	9.55	7.55	4.35	3.70	3.85	5.80	5.90	5.30	.....
28	.....	[a] 4.50	.....	9.75	7.50	4.45	3.80	3.70	5.80	5.90	5.20	.....
29	.....	.....	.....	9.95	7.20	4.60	3.80	3.70	5.70	6.00	5.20	.....
30	.....	.....	.....	10.30	6.75	4.60	3.90	3.65	5.75	5.85	5.20	.....
31	[a] 4.20	.....	.....	.....	6.50	.....	3.90	3.65	.....	5.65	.....	.....

[a] Ice 1.7 feet thick.
[b] River frozen over.
[c] Ice 0.4 foot thick.
[d] Ice 1.4 feet thick.

NOTE.—During frozen season gage readings are to surface of water in hole cut in ice.

Rating table of Mattawamkeag River at Mattawamkeag, Me., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.7	110	3.9	630	5.4	2,350	7.8	6,800
2.75	121	4.0	710	5.5	2,500	8.0	7,260
2.8	133	4.1	790	5.6	2,650	8.2	7,740
2.85	146	4.2	880	5.7	2,810	8.4	8,235
2.9	160	4.3	975	5.8	2,970	8.6	8,740
2.95	175	4.4	1,075	5.9	3,135	8.8	9,260
3.0	191	4.5	1,175	6.0	3,305	9.0	9,780
3.1	226	4.6	1,285	6.2	3,645	9.5	11,170
3.2	262	4.7	1,400	6.4	3,995	10.0	12,570
3.3	300	4.8	1,520	6.6	4,355	10.5	14,070
3.4	340	4.9	1,650	6.8	4,725	11.0	15,600
3.5	382	5.0	1,790	7.0	5,110	11.5	17,200
3.6	432	5.1	1,930	7.2	5,510		
3.7	490	5.2	2,070	7.4	5,930		
3.8	556	5.3	2,210	7.6	6,360		

The above table is applicable only for open-channel conditions. It is based upon 16 discharge measurements made during 1902 to 1904, inclusive. It is well defined between gage heights 2.7 feet and 10 feet. The table has been extended above gage height 10 feet. Below gage height 7.2 feet the table is the same as the 1903 table.

Estimated monthly discharge of Mattawamkeag River at Mattawamkeag, Me., for 1904.

[Drainage area, 1,510 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
April 8–30	13,470	6,360	10,360	6.86	5.87
May	17,840	4,175	11,590	7.68	8.85
June	5,210	1,025	3,088	2.04	2.28
July	1,650	432	1,014	.672	.775
August	710	340	534	.354	.408
September	2,970	340	1,440	.954	1.06
October	4,355	1,790	2,725	1.80	2.08
November	2,350	1,075	1,743	1.15	1.28
December 1–20	2,970	1,790	2,359	1.56	1.16

PISCATAQUIS RIVER NEAR FOXCROFT, ME.

This station was established August 17, 1902, by F. E. Pressey. It is located at Low's bridge, about halfway between Guilford and Foxcroft. The area of the drainage basin at this point is 280 square miles. The initial point for soundings is on the left bank at the top of the face of the left abutment. The gage is a painted staff spiked to the left abutment. It is referred to bench marks as follows: (1) Top of second course from top of left abutment; elevation, 17.80 feet. (2) Copper bolt in ledge, 150 feet north of highway and 75 feet west of river; elevation, 20.97 feet. (3) Marked point on bottom chord of upstream truss of bridge, 30 feet from initial point; elevation, 21.80 feet. All elevations are above gage datum. The channel both above and below the station is straight and has a width of about 90 feet at ordinary stages. The banks are high and rocky; the bed is rough and rocky, but permanent.

Observed mean velocities at the station have been between 3.63 feet per second at gage height 4.30 feet and 0.54 of a foot at gage height 2 feet. Low-water measurements are made by wading, either above or below the bridge, at points where the bed is fine gravel, and the velocity is greater than at the bridge. Water power is used at several manufacturing plants within a few miles above the station. As a result of the interruptions, due to the irregular use of water at the mills, the river fluctuates, at low stages, through nearly a foot on the gage within the day. The small amount of stored water in this basin is generally used for log driving. Slopes are steep. The river rises and falls rapidly. Probably 50 per cent of the basin is in forest. The gage is read twice daily by A. F. D. Harlow.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Piscataquis River near Foxcroft, Me., 1902–1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
1902.		*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
August 13	F. E. Pressey	317	3.15	3.70	1,000
August 16	do	199	1.67	2.80	332
September 10	do	189	1.52	2.75	288
October 18	do	112	.54	2.00	61
1903.					
April 6	F. E. Pressey	409	3.63	4.30	1,490
May 14	E. G. Hartford	210	1.76	2.80	370
May 14	do	210	1.76	2.79	368
June 12	F. E. Pressey	156	1.03	2.48	160
June 12	do	164	1.27	2.64	208
June 12	do	156	1.08	2.47	169
September 16	N. C. Grover	136	.82	2.19	112
October 3[a]	do	11	2.00	1.52	22
October 31[a]	F. E. Pressey	22	1.41	1.78	31
October 31[a]	do	118	.67	1.94	79
October 31[a]	do	79	.47	1.78	37
November 24[a]	do	139	1.30	2.50	181
1904.					
April 22	F. E. Pressey	355	3.35	4.00	1,190
May 13	do	610	6.31	5.92	3,850
May 13	do	620	6.31	5.98	3,910
June 2	N. C. Grover	208	1.99	2.90	415

[a] Measurements by wading.

Mean daily gage height, in feet, of Piscataquis River near Foxcroft, Me., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.0	3.8	3.0	4.7	7.0	2.4	3.2	2.3	2.0	4.0	3.2	2.4
2	3.0	3.4	3.0	4.6	5.6	2.3	3.4	2.4	2.0	4.0	3.2	2.8
3	3.0	3.0	3.0	4.5	5.2	2.8	3.7	2.2	2.0	3.6	3.0	2.8
4	3.1	2.9	3.1	4.3	5.5	2.3	3.7	2.1	2.5	3.5	3.0	2.6
5	3.0	2.8	3.3	4.2	4.9	2.7	3.6	2.1	2.6	3.2	3.0	2.8
6	3.2	2.8	3.6	5.0	4.8	3.4	3.2	2.1	2.6	3.2	2.8	2.7
7	3.2	2.2	3.6	5.0	4.6	4.2	3.2	2.1	2.6	3.0	3.0	2.6
8	3.0	2.8	3.8	5.5	3.8	3.6	3.0	2.1	2.6	3.0	3.0	2.6
9	2.9	2.8	4.4	5.8	4.0	3.3	3.0	2.2	2.6	2.4	3.0	2.6
10	2.5	2.8	4.9	7.0	6.4	3.2	2.9	2.2	2.2	2.2	3.0	2.6
11	3.2	2.8	5.2	10.2	6.9	2.6	2.9	2.4	3.6	2.6	3.0	2.7
12	3.2	2.6	5.0	8.6	8.2	2.0	2.9	2.4	3.3	2.6	3.0	2.6

Mean daily gage height, in feet, of Piscataquis River near Foxcroft, Me., for 1904—Con.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
13	3.2	2.5	4.6	6.2	6.2	2.0	3.0	2.4	2.2	2.6	2.6	2.7
14	3.4	2.6	4.6	4.6	5.4	2.3	3.2	2.4	2.3	2.6	3.0	2.5
15	3.4	2.8	4.5	4.2	4.4	2.3	3.2	2.7	2.8	2.7	3.1	2.4
16	3.5	2.8	4.4	4.0	5.8	2.5	3.0	2.6	3.5	2.6	3.6	2.4
17	3.5	2.8	4.2	3.8	6.6	2.7	2.8	2.6	3.0	2.6	3.2	2.4
18	3.7	2.8	4.2	3.6	5.6	2.7	2.8	2.6	2.8	2.6	3.0	2.1
19	3.9	2.7	3.9	3.8	4.8	2.7	2.7	2.6	3.0	2.6	2.8	2.8
20	3.4	2.4	3.8	4.0	5.0	2.7	2.7	2.6	3.0	2.6	2.6	3.0
21	3.2	2.0	3.8	4.1	4.4	2.7	2.7	2.9	2.8	3.0	2.8	2.8
22	3.2	2.4	3.8	4.0	4.2	2.6	2.6	3.0	2 8	4.5	2.9	2.8
23	3.3	2.8	3.6	4.0	4.3	2.6	2.5	2.9	2.8	3.9	3.0	2.8
24	3.2	3.0	4.3	4.8	4.0	2.6	2.4	2.7	2.7	3.5	2.8	2.8
25	3.7	3.2	4.4	5.2	3.7	2.6	2.3	2.6	2.6	3.2	2.9	2.6
26	3.2	3.0	4.6	5.4	3.0	2.5	2.3	2.6	2.6	3.4	2.8	2.8
27	3.4	3.0	5.1	5.4	3.6	3.1	2.3	2.3	2.7	4.0	2.5	2.8
28	3.2	3.0	5.2	5.4	3.5	3.0	2.4	2.2	2.7	3.8	2.6	3.2
29	2.9	2.9	5.0	6.0	3.3	2.7	2.3	2.4	2.8	3.5	2.6	3.0
30	3.0	.....	4.8	6.7	3.4	2.6	2.8	2.2	4.0	3.4	2.4	2.8
31	3.0	.....	4.6	.....	3.4	.....	2.3	2.1	.....	3.2	.....	2.8

Rating table of Piscataquis River near Foxcroft, Me., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.0	64	2.7	267	3.8	1,023	5.2	2,635
2.05	72	2.75	292	3.9	1,113	5.3	2,785
2.1	81	2.8	318	4.0	1,208	5.4	2,940
2.15	90	2.85	345	4.1	1,303	5.5	3,100
2.2	100	2.9	374	4.2	1,403	5.6	3.265
2.25	111	2.95	405	4.3	1,508	5.8	3,610
2.3	123	3.0	437	4.4	1,615	6.0	3,970
2.35	135	3.1	502	4.5	1,725	6.2	4,335
2.4	148	3.2	569	4.6	1,840	6.4	4,705
2.45	163	3.3	638	4.7	1,960	6.6	5,080
2.5	180	3.4	709	4.8	2,085	6.8	5,460
2.55	199	3.5	782	4.9	2,215		
2.6	220	3.6	858	5.0	2,350		
2.65	243	3.7	938	5.1	2,490		

The above table is applicable only for open-channel conditions. It is based upo 20 discharge measurements made during 1902 to 1904, inclusive. It is well defined between gage heights 1.5 feet and 6.0 feet. The table has been extended beyond these limits.

Estimated monthly discharge of Piscataquis River near Foxcroft, Me., for 1904.

[Drainage area, 280 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	1,113	180	587	2.10	2.42
February	1,023	64	348	1.24	1.34
March	2,635	437	1,459	5.21	6.01
April	15,050	858	3,004	10.7	11.9
May	8,840	437	2,532	9.04	10.4
June	1,403	64	319	1.14	1.27
July	938	123	388	1.39	1.60
August	437	81	174	.621	.716
September	1,208	64	325	1.16	1.29
October	1,725	100	587	2.10	2.42
November	858	148	395	1.41	1.57
December	569	81	273	.975	1.12
The year	15,050	64	866	3.09	42.06

COLD STREAM AT ENFIELD, ME.

Cold Stream is the outlet from Cold Stream Pond—really a series of ponds comprising a total area of water surface of about 10 square miles, the largest, which is mostly in the town of Enfield, having about 8 square miles area.

Cold Stream flows into Passadumkeag Stream, a tributary of the Penobscot, at a distance of some 4½ miles from Cold Stream Pond, and has a total drainage area of about 37 square miles. The basin is mostly wooded and only sparsely settled. During the first half mile the fall is rapid, but through the rest of its course the stream runs through a great swamp, and is tortuous in its course, with sluggish current. Near the village of Enfield a fall of perhaps 10 to 12 feet has in the past been developed for power for a saw and shingle mill, but is not now in use. This drainage basin has been considered as a source of water supply for the district, which includes Bangor and some other adjacent towns.

This station was established June 14, 1904, by N. C. Grover, and was located at the highway bridge, about three-fourths of a mile south of Enfield, on the road to Passadumkeag. During the summer it was found that the gage was within the influence of back water from Passadumkeag Stream, and consequently, on September 12, 1904, the gage was taken from the highway bridge mentioned above and placed

about 200 feet below the old mill, near Enfield post-office. The drainage area at this point is about 26 square miles.

The gage is a standard chain, attached to a clump of maple trees on the right bank of the river; length of chain, 10.24 feet. It is referred to the following bench marks: (1) Spike in maple tree near the gage; elevation, 6.89 feet above gage datum. (2) Point on a rock marked "B. M.—2," about 8 feet downstream from the gage on the right bank; elevation, 4.55 feet above gage datum. (3) Center of the gage-box pulley; elevation, 9.03 feet above gage datum. Discharge measurements are made at low and medium stages by wading in the vicinity of the gage. High-water measurements are made from the bridge about 600 feet above the gage. The stream is fairly straight in the vicinity of the gage, and is about 30 feet wide at ordinary stages. The bed of the stream is rocky and permanent; the banks are not high and probably overflow at high stages. The width is about 30 feet; depth about 0.9 of a foot; velocity is high at all stages. The gage is read daily by Mr. A. J. Twombley, a farmer, at Enfield.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Cold Stream at Enfield, Me., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Square feet.	*Ft. per sec.*	*Feet.*	*Second-feet.*
September 9	H. K. Barrows	17	2.12	2.72	36
October 12	F. E. Pressey	20	1.85	2.75	37
October 21	do	23	2.43	2.92	56
November 4	do	25	2.16	2.90	54

Mean daily gage height, in feet, of Cold Stream at Enfield, Me., for 1904.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1		2.9	2.9	2.6	17	2.9	3.0	2.7	2.7
2		2.9	2.8	2.7	18	2.9	3.0	2.9	2.7
3		2.9	2.8	2.7	19	2.8	3.0	2.8	2.6
4		2.9	3.0	2.7	20	2.8	3.0	2.7	2.7
5		3.0	2.8	2.8	21	2.8	2.8	2.8	2.6
6		2.8	2.8	2.8	22	2.8	3.0	2.8	2.7
7		2.8	2.8	2.7	23	2.8	3.0	2.7	2.7
8		2.8	2.8	2.7	24	2.9	3.0	2.6	2.7
9		2.9	2.8	2.7	25	2.9	3.0	2.7	2.6
10	2.4	2.8	2.8	2.8	26	2.8	3.0	2.8	2.6
11	2.8	2.5	2.8	2.7	27	2.8	3.0	2.8	2.7
12	2.8	2.7	2.8	2.8	28	2.8	3.0	2.8	2.7
13	2.7	2.7	2.7	2.8	29	2.8	3.0	2.7	2.6
14	2.7	2.7	2.7	2.7	30	3.0	3.0	2.6	2.7
15	2.9	2.7	2.7	2.6	31		3.0		2.6
16	2.9	2.8	2.7	2.6					

PHILLIPS LAKE AND OUTLETS IN HOLDEN AND DEDHAM, ME.

Phillips Lake drains an area of about 11.5 square miles, and has a water surface of about 1.4 square miles. It is situated about 10 miles southeast of the city of Bangor. The shores are generally rocky and the adjacent country mostly wooded and only sparsely settled. The water is apparently of excellent quality and of considerable depth. This lake is being prominently considered as a new source of water supply for the city of Bangor. There are two drainage outlets of this lake. The greater amount of water flows from the northern end of the lake northerly through the village of East Holden; thence southerly through Long Pond and into Penobscot River below Bucksport. The total length of this outlet is 18 miles. The other outlet, situated at the southeast end of the lake in the town of Dedham, flows into Green Lake and thence into Union River. Through this outlet there is flow only during medium and high stages.

The United States Geological Survey maintains gages at the two outlets of the lake; also a gage for obtaining a record of lake level.

The station at the northern outlet was established July 7, 1904, by F. E. Pressey. It is located about 1¼ miles from the lake, one-fourth mile south of the village of East Holden and 175 feet south of an old mill. The drainage area at this point is 12.3 square miles. A plain staff gage was first used, attached vertically to a maple tree on the right bank, but this was replaced on December 6, 1904, by a standard chain gage attached to the same maple tree; length of chain, 9.48 feet. The gage is referred to bench marks as follows: (1) A spike, approximately vertical, in the foot of the tree to which the gage is attached, inclosed in a circle and marked "B. M.—1"; elevation, 5.24 feet above the gage datum. (2) The highest point on a large stone about 25 feet upstream from the gage in the bed of the stream. It is inclosed in a circle and marked "B. M.—2"; elevation, 5.51 feet above gage datum. (3) Spike driven into maple tree to which gage is attached, approximately horizontal, for use in measuring to the water surface; elevation, 6.17 feet above gage datum. (4) Center of gage-box pulley; elevation, 8.30 feet above gage datum.

Discharge measurements are made at ordinary stages by wading near the gage. At high water they are made from a railroad bridge about one mile upstream. The channel is straight for about 10 or 12 feet above the gage and curved just below the gage. The bed is rocky and rough but permanent. The banks are high and not subject to overflow. There is but one channel at all stages. The ordinary width is about 10 feet; depth, 0.8 of a foot; velocity, high at all stages. The gage is read once each day by Lewis Pinkham, of East Holden.

The station at the southeast outlet was established July 19, 1904, by H. K. Barrows. It is located at the highway bridge about 1½ miles

southeast of Lake House railroad station, and is about 700 feet southeast of the Maine Central Railroad crossing. A plain staff gage is fastened vertically to the logs of the floor and the right abutment of the single-span highway bridge. It is referred to bench marks as follows: (1) A point and circle on stone of the southeast abutment of the bridge marked "B. M.—1"; elevation, 6.31 feet above the gage datum. (2) Highest point of stone about 50 feet north of the gage on the west side of the road, inclosed by a circle and marked "B. M.—2"; elevation, 10.04 feet above the gage datum.

Discharge measurements are made at low and medium stages by wading just below the bridge, and at high stages from the downstream side of the bridge to which the gage is attached. The channel is curved for about 25 feet above the station and straight for some 30 feet below. The bed of the stream is of gravel, rough but permanent. The banks are rocky, wooded, and liable to overflow. There is but one channel at all stages. The gage is read only when meter measurements are made.

The station on Phillips Lake was established July 19, 1904, by H. K. Barrows. It is located about one-fourth mile west of Lake House railroad station. The gage is a plain, vertical staff fastened to a bowlder on the east shore of the lake about 300 feet northwest of Dr. L. S. Chilcott's cottage. It is referred to bench marks as follows: (1) A point on ledge of rock east of the gage, inclosed by a circle and marked "B. M.—1"; elevation, 10.28 feet above gage datum. (2) A point on a ledge of rock about 10 feet west of the gage, inclosed by a circle and marked "B. M.—2"; elevation, 11.86 feet above gage datum. This gage has been read at intervals of a week or two, and results furnished through the courtesy of Dr. L. S. Chilcott, of Bangor, during the summer and fall of 1904.

An additional vertical staff gage, referred to the same datum, was established on December 6, 1904. It is fastened to the east abutment of the Maine Central Railroad bridge over the northern end of Phillips Lake. It is referred to bench marks as follows: (1) The northwest corner of wing wall at west end of bridge; elevation, 16.79 feet above gage datum. This gage is read once a week by H. C. Lord, section foreman of the Maine Central Railroad, who lives at East Holden.

Observations at these stations during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Phillips Lake, north outlet, at East Holden, Me., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Square feet.	*Ft. per sec.*	*Feet.*	*Second-feet.*
July 19	H. K. Barrows	7.86	1.23	1.55	9.66
August 18	F. E. Pressey	6.54	.97	1.45	6.29
October 17	do	4.36	1.29	1.46	5.64

Discharge measurements of Phillips Lake, southeast outlet, near Greenlake, Me., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Square feet.	*Ft. per sec.*	*Feet.*	*Second-feet.*
July 19	H. K. Barrows	1.23	0.89	1.42	1.09
August 18	F. E. Pressey	.20	.35	1.14	.07
October 17	do	1.25	1.18	1.49	1.48

Mean daily gage height, in feet, of Philips Lake, north outlet, at East Holden, Me., for 1904.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	1.70	1.45	(a)	1.45	1.80
2	.....	1.70	1.50	.....	1.45	1.90
3	.....	1.65	1.48	.....	1.45	2.00
4	.....	1.65	1.45	.....	1.45	1.80
5	.....	1.65	1.45	.....	1.45	1.70
6	.....	1.60	1.45	.....	1.45	1.70
7	1.60	1.60	1.45	.....	1.45	1.70
8	1.60	1.60	1.45	.....	1.45	1.70
9	1.60	1.60	1.45	.....	1.45	1.70
10	1.60	1.55	1.42	.....	1.45	1.65
11	1.60	1.55	1.40	.....	1.45	1.65
12	1.60	1.55	1.40	.....	1.45	1.65
13	1.60	1.48	1.40	.....	1.45	1.70
14	1.55	1.45	1.40	.....	1.45	1.70
15	1.50	1.40	1.40	.....	1.45	1.65
16	1.50	1.40	1.40	.....	1.45	1.65
17	1.50	1.40	1.40	1.45	1.45	1.65
18	1.50	1.40	1.40	1.45	1.45	1.65
19	1.52	1.40	1.40	1.45	1.45	1.70
20	1.55	1.40	1.40	1.45	1.45	1.65
21	1.52	1.62	1.40	1.45	1.50	1.70
22	1.50	1.50	1.40	1.45	1.50	1.75
23	1.50	1.48	1.40	1.45	1.50	1.70
24	1.50	1.45	1.40	1.45	1.55	1.60
25	1.50	1.45	1.40	1.45	1.60	1.65
26	1.50	1.45	1.40	1.45	1.65	1.65
27	1.55	1.45	1.40	1.45	1.70	1.65
28	1.70	1.45	1.40	1.45	1.75	1.70
29	1.70	1.48	1.40	1.45	1.75	1.65
30	1.70	1.45	1.40	1.45	1.75	1.65
31	1.70	1.45	.....	1.45	.....	1.65

a No gage readings October 1–16.

Mean daily gage height, in feet, of Phillips Lake, at East Holden, Me., for 1904.

Day.	July.	Aug.	Oct.	Dec.	Day.	July.	Aug.	Oct.	Dec.
6	.....	6.50	.....	8.30	19	7.05	.....	.....	.....
14	.....	6.37	.....	.....	21	.....	6.62	.....	.....
17	.....	.....	7.34	.....	22	.....	6.70	.....	.....
18	.....	6.40	.....	.....	31	6.70	.....	.....	.....

KENNEBEC RIVER DRAINAGE BASIN.

Kennebec River is one of the best streams in the United States for the development of water power. Its basin, which lies wholly within the State of Maine, between those of the Androscoggin and the Penobscot, is 150 miles in length and from 50 to 80 miles in width in the main portion, embracing a total area of 6,110 square miles. Of this area 1,330 square miles are tributary to Moosehead Lake, in which the river has its source. The upper tributaries, however, rise in the hilly, forested areas lying to the east and west of that lake. Of these, Moose River is the most important. The northern part of the drainage basin is broken by offsets from the White Mountains. Nearly the whole of the upper portion is forest covered and in its original wild state.

Below the outlet of Moosehead Lake the hills close in upon the river, forming a narrow, rocky chasm, with steep and precipitous sides. From Moosehead Lake to The Forks the river is a torrent, the total fall in the 23 miles being 500 feet. Dead River is tributary to the Kennebec at The Forks. Below this junction the river flows with a lesser slope in a narrow, winding bed about 20 miles to Bingham; thence through a broader valley in which are located many farms. There are between Bingham and tide water a number of large falls at which water power has been developed.

The prevailing rock in the northern part of the basin is slate, with a belt of sandstone to the west and a district of granite to the east of Moosehead. South of Bingham mica-schists run into the clay slate in spots and elsewhere into gneiss, but (except where broken by intrusions of granite, as at Hallowell and Augusta) slate prevails as far as Gardiner. Below the latter city gneiss predominates, with stretches of mica-schists on the east bank. The surface materials are finely pulverized. Water-retaining sands and gravels are more abundant in the northern part, succeeded by a greater proportion of loam and clay to the south.

The areas of the drainage basins of the river and its principal tributaries are given in the following table.

Drainage areas of Kennebec River and principal tributaries.

River.	Locality.	Drainage area.
		Square miles.
Kennebec	Outlet of Moosehead Lake	1,330
Do	The Forks	1,670
Do	Immediately below mouth of Dead River	2,540
Do	Caratunk Falls, Solon	2,790
Do	North Anson, above mouth of Carrabassett River.	2,880
Do	Madison	3,310
Do	Norridgewock	4,020
Do	Fairfield	4,370
Do	Waterville, above mouth of Sebasticook River.	4,380
Do	Waterville, below mouth of Sebasticook River.	5,310
Do	Augusta	5,710
Do	Head of Merrymeeting Bay	6,110
Moose	Mouth	680
Roach	Roach River	85
Dead	Mouth, The Forks	870
Carrabassett	North Anson, above Embden Brook	340
Do	Mouth	395
Sandy	Farmington	350
Do	Mouth	670
Sebasticook	.....do	930
Messalonskee	.....do	208
Cobbosseecontee	.....do	240

The United States Geological Survey now maintains gaging stations at the following places in the Kennebec drainage: On the Kennebec at The Forks and at North Anson; on Moose River at Rockwood; on Roach River at Roach River; on Dead River at The Forks; on Carrabassett River at North Anson; on Sandy River near Madison; on Messalonskee River at Waterville.

In addition, figures of flow are furnished the Survey by private parties for Kennebec River at Waterville, and Cobbossecontee River at Gardiner.

KENNEBEC RIVER AT THE FORKS, ME.

This station was established by N. C. Grover, September 28, 1901, at the wooden highway bridge across Kennebec River at The Forks, above the mouth of Dead River. The drainage area at the station is 1,670 square miles. Of this area 1,330 square miles are tributary to

Moosehead Lake, while the remaining 340 square miles are drained into the Kennebec by small streams with steep slopes and no storage. Practically all land surfaces above this point are in forest. There are two gages—one, a vertical rod, is attached to the timber retaining wall on the left bank about 75 feet above the bridge; the other is of the standard chain type, and is attached to the bridge floor; length of chain, 17.18 feet. The datum of the two gages is the same and is referred to two bench marks; (1) the top of a bolt on the east abutment, north side of bridge; elevation, 12.85 feet above gage datum; (2) marked point on the floor of the bridge near the east end of the gage box; elevation, 15.42 feet above gage datum; gage datum is at elevation 562.85 feet above mean sea level, as determined by the Kennebec River survey of 1904. The initial point of soundings is on the left bank, marked by a rod across the bridge, just above the abutment and below the bridge floor. The channel is straight above the station for about 200 feet and below for a distance of 500 feet, is unbroken by piers, and is about 125 feet wide at ordinary stages of the river. The current is swift; observed mean velocities ranged from 7.67 feet per second at gage height, 5.60 to 0.86 of a foot per second at gage height 0.90. The banks are high and rocky and the bed is rocky and permanent. The gage is read twice daily by William W. Young.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Kennebec River at The Forks, Me., 1901–1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
1901.		*Square feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
September 28	N. C. Grover	774	2.40	2.60	1,860
October 20	do	550	.86	.90	473
1902.					
April 25	N. C. Grover	930	3.76	3.70	3,500
June 16	do	1,160	7.64	5.60	8,860
June 25	do	1,050	5.61	4.75	5,900
September 29	F. E. Pressey	730	2.03	2.10	1,480
1903.					
August 18	N. C. Grover	979	4.27	3.95	4,180
November 4	do	614	1.23	1.26	757
November 4	do	614	1.24	1.26	759
1904.					
July 27	H. K. Barrows	650	1.63	1.70	1,060
August 29	do	863	3.15	3.12	2,720

Mean daily gage height, in feet, of Kennebec River at The Forks, Me., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.90	2.30	a 2.40	2.00	4.85	5.75	4.10	2.25	3.05	2.60	1.45	2.10
2	b 1.90	.....	.....	.....	4.25	5.65	4.20	2.40	3.10	2.35	1.40	2.10
3	.....	.....	.....	1.50	3.70	6.25	4.75	3.70	3.60	2.05	1.40	2.10
4	.....	c 2.30	.....	.80	3.50	5.90	4.60	3.25	4.10	1.85	1.40	d 2.50
5	.....	.....	.....	.80	3.40	6.30	4.40	3.30	4.05	1.95	1.55	e 2.40
6	.....	.....	.....	.90	3.40	5.90	4.10	3.25	3.85	1.50	1.70	e 2.40
7	a 2.00	.....	a 2.20	1.10	3.30	6.40	4.15	3.15	3.30	1.35	2.50	f 2.60
8	.....	.....	2.40	g 1.20	3.30	4.75	3.95	3.10	3.05	1.30	2.65	h 2.70
9	a 1.90	.....	2.50	g 6.80	3.20	5.35	4.00	3.05	2.90	1.30	2.15	f 2.80
10	.....	.....	a 2.50	g 2.60	3.70	5.10	4.05	3.35	2.80	1.60	2.10	h 3.10
11	.....	c 2.60	.....	g 3.20	5.30	6.10	4.30	3.25	2.70	2.30	1.95	f 3.20
12	e 1.90	f 2.60	a 2.30	g 3.70	4.80	6.30	4.85	3.65	2.60	2.85	2.00	3.30
13	1.90	f 2.60	.....	2.80	4.00	7.00	5.25	3.55	2.60	3.05	2.15	3.30
14	2.10	.....	.....	2.80	3.20	6.90	5.30	3.75	2.65	3.10	2.30	3.50
15	.....	2.60	.....	3.10	4.10	4.20	5.20	3.30	2.95	3.10	2.20	3.50
16	c 2.00	.....	a 2.10	3.10	4.30	4.20	6.10	2.10	2.20	3.05	2.30	3.80
17	.....	.....	.....	2.90	4.65	4.45	5.50	3.90	1.90	3.00	2.20	3.80
18	.....	c 2.40	.....	1.80	4.80	3.90	4.40	3.35	1.80	2.65	2.20	4.00
19	c 2.00	.....	2.30	2.10	5.65	3.90	4.15	3.50	1.70	2.40	2.15	4.10
20	.....	2.40	f 2.40	1.70	5.30	k 7.50	4.10	3.40	1.50	2.30	2.10	4.10
21	c 2.00	.....	2.40	1.70	4.90	.....	4.00	2.35	1.50	2.25	2.15	4.20
22	c 2.00	.....	.....	1.80	3.10	k 4.60	5.85	2.30	1.70	2.55	2.10	4.40
23	.....	.....	.....	1.90	5.25	k 3.85	2.15	1.50	1.75	2.30	2.05	4.20
24	.....	.....	2.40	2.65	4.25	k 3.85	6.10	1.75	2.00	2.05	2.05	4.40
25	c 2.30	.....	2.40	3.35	5.60	k 3.90	4.20	2.00	2.60	2.40	2.00	4.60
26	.....	.....	2.40	3.20	4.50	4.35	3.60	2.25	2.60	2.25	2.00	4.60
27	.....	c 2.40	2.40	3.25	4.55	4.35	3.50	2.55	2.55	2.00	2.05	4.60
28	c 2.30	.....	2.30	3.30	4.45	4.30	3.40	3.10	2.70	1.70	2.00	4.80
29	c 2.40	.....	2.30	3.40	5.50	4.10	3.70	3.20	2.55	1.80	2.00	4.50
30	.....	.....	2.10	3.95	5.55	4.00	3.40	3.10	2.70	1.55	2.10	4.80
31	.....	.....	2.20	.....	5.25	.....	3.05	3.10	.....	1.50	.....	4.70

a Ice 2.2 feet thick. *b* Ice 1.4 feet thick. *c* Ice 2 feet thick.

Anchor ice caused backwater effect on gage estimated as follows:

d 0.4 foot.
e 0.3 foot.
f 0.5 foot.
g Ice from Dead River formed a jam a short distance below gage and caused backwater.
h 0.6 foot.
i 0.7 foot.
j Ice 2.1 feet thick.
k Log jam formed short distance below gage caused estimated backwater effect on gage of 0.3 foot.

NOTE.—During frozen season gage readings are to surface of water in hole cut in ice.

Rating table for Kennebec River at The Forks, Me., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.9	480	1.6	1,040	2.7	2,000	4.4	5,020
.95	520	1.7	1,120	2.8	2,105	4.6	5,510
1.0	560	1.8	1,200	2.9	2,220	4.8	6,040
1.05	600	1.9	1,285	3.0	2,350	5.0	6,620
1.1	640	2.0	1,365	3.1	2,490	5.2	7,280
1.15	680	2.1	1,445	3.2	2,635	5.4	8,010
1.2	720	2.2	1,525	3.4	2,950	5.6	8,780
1.25	760	2.3	1,610	3.6	3,310	5.8	9,620
1.3	800	2.4	1,700	3.8	3,700	6.0	10,510
1.4	880	2.5	1,800	4.0	4,120		
1.5	960	2.6	1,900	4.2	4,560		

The foregoing table is applicable only for open-channel conditions. It is based upon 11 discharge measurements made during 1901 to 1904, inclusive. It is well defined between gage heights 1 foot and 5 feet. Above 6 feet gage height the discharges are estimated by logarithmic extension of the discharge curve.

Estimated monthly discharge of Kennebec River at The Forks, Me., for 1904.

[Drainage area, 1,670 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
April (10–30)	4,015	1,120	2,226	1.33	1.04
May	8,780	2,635	5,255	3.15	3.63
June	18,090	3,805	8,001	4.79	5.34
July	10,960	1,485	5,232	3.13	3.61
August	3,910	960	2,440	1.46	1.68
September	4,330	960	2,078	1.24	1.38
October	2,490	800	1,565	.937	1.08
November	1,950	880	1,377	.825	.920

KENNEBEC RIVER NEAR NORTH ANSON, ME.

This station was established on October 18, 1901, by N. C. Grover. It is located 1½ miles east of North Anson, above the mouth of Carrabassett River. The drainage area at this point is 2,880 square miles. Measurements are made from the wooden highway bridge across the Kennebec, known locally as Patterson Bridge. There are three gages: One is a vertical rod fastened to the bridge pier; another, for high-water observations, is a vertical rod attached to the right abutment; the third is a low-water gage of the standard chain type, and is attached to the wooden truss on the upstream side of the bridge; length of chain, 30.40 feet when gage was established, but changed to 30.36 feet, July 26, 1904, owing to settlement of bridge. Gage datum is elevated 241.24 feet above mean sea level, as determined by the Kennebec River survey of 1904. The datum of the three gages is the same and is referred to four bench marks: (1) Top of pier back of the gage; elevation, 22.50 feet. (2) Top of the southeast corner of the twelfth stone from the top of west abutment; elevation, 9.55 feet. (3) Copper bolt in bowlder on right bank about 100 feet above the bridge; elevation, 10.66 feet. (4) Marked point on the bottom chord of the bridge near the chain gage; elevation, 25.15 feet originally; changed to 25.03, July 26, 1904. The initial point for soundings is on the left bank at the outside of the end post of the center truss of the bridge. The channel is straight above the station for 500 feet and below for 1,000 feet and has a width of about 350 feet, broken by one pier The current is

moderately rapid, except near the left bank; observed mean velocities at the station have ranged from 3.65 feet per second at gage height 6.80 feet to 1.40 feet per second at gage height 2.85. Low-water measurements are made from a boat about 1,000 feet below the station at a section where there is a better distribution of current. The right bank is high and rocky, while the left bank is comparatively low and subject to overflow at the time of highest water. The bed of the stream is rocky, with sand over a portion of the section, and is permanent. The gage is read twice daily by Mrs. C. S. Benjamin, the toll collector at the bridge.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Kennebec River near North Anson, Me., 1901–1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
1901.		*Square feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
October 14	N. C. Grover	1,540	2.02	3.20	3,120
October 18	do	1,500	1.64	3.00	2,460
1902.					
July 29	F. E. Pressey	2,390	2.60	4.55	6,220
1903.					
March 28	F. E. Pressey	2,900	3.93	6.50	11,400
May 27	do	1,970	1.59	3.25	3,130
June 15	do	3,050	3.64	6.80	11,100
June 16	do	2,424	2.79	4.90	6,740
June 16	do	2,250	2.48	4.38	5,580
July 17	do	1,920	1.54	3.25	2,960
August 15	do	2,120	1.89	3.78	4,000
September 24	N. C. Grover	1,790	1.40	2.85	2,500
November 6	F. E. Pressey	428	2.83	2.00	[a] 1,200
1904.					
January 27	F. E. Pressey	393	1.90	[b] 3.40	749
January 28	do	398	1.97	[b] 3.40	786
March 2	do	285	1.86	[c] 3.55	529
March 4	do	285	2.01	[c] 3.65	572
June 10	do	2,770	3.09	6.00	8,560
July 26	H. K. Barrows	1,780	1.35	2.94	2,400
August 30	do	1,940	1.65	3.43	3,210

[a] Different section.
[b] River frozen. Gage height to water surface. Ice 2.2 feet thick.
[c] River frozen. Gage height to water surface. Ice 2.5 feet thick.

Mean daily gage height, in feet, of Kennebec River near North Anson, Me., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	[a] 3.60	[b] 4.80	9.65	6.00	4.30	5.00	3.40	5.70	3.05	[c] 6.05
2	3.70	.....	[a] 3.60	4.90	8.65	6.00	4.55	4.50	3.40	5.05	2.95	.....
3	.....	.....	[a] 3.60	4.90	8.70	5.20	4.90	4.20	3.65	4.55	2.75	.....
4	.....	.....	[a] 3.60	4.90	7.75	5.20	4.75	4.40	4.20	3.95	2.75	.....
5	.....	.....	[a] 3.60	4.90	7.25	5.70	4.50	4.70	4.65	3.80	2.75	.....
6	.....	[d] 3.50	.....	5.00	7.40	6.05	4.30	4.80	4.25	3.40	2.80	[e] 5.00
7	.....	.....	.....	5.15	7.15	7.40	4.25	4.10	4.00	3.15	3.15	.....
8	.....	.....	.....	5.50	6.05	6.90	4.10	4.50	3.80	3.00	3.45	.....
9	[f] 3.50	.....	.....	5.75	6.70	6.35	4.05	3.60	3.60	2.95	3.35	.....
10	.....	.....	.....	[g] 6.85	9.10	6.60	3.95	3.45	3.45	2.95	3.15	.....
11	.....	.....	[h] 4.00	8.45	8.50	6.45	3.95	3.25	3.15	3.15	3.20	.....
12	.....	.....	[i] 4.40	10.10	10.70	5.85	5.00	3.30	3.20	3.35	3.20	.....
13	.....	[f] 3.20	.....	8.60	8.35	5.60	5.60	3.90	3.15	3.70	3.15	.....
14	.....	.....	.....	6.80	7.00	5.35	5.35	3.50	3.15	3.80	3.30	.....
15	.....	.....	.....	5.00	6.10	5.05	5.10	3.40	3.45	3.75	3.15	.....
16	[f] 3.40	.....	.....	4.90	9.90	5.05	5.10	3.95	3.95	3.75	3.15	[j] 4.00
17	.....	.....	.....	4.40	9.95	4.80	4.80	4.90	3.90	3.90	3.15	.....
18	.....	.....	.....	4.00	8.15	4.50	4.80	4.50	3.40	3.75	3.15	.....
19	.....	.....	[k] 4.20	3.65	7.35	4.50	4.80	3.65	3.20	3.30	3.05	.....
20	.....	[f] 3.50	.....	4.25	7.35	4.60	3.85	3.85	3.00	3.25	2.95	.....
21	.....	.....	.....	4.10	6.35	4.95	4.00	4.20	2.90	3.20	3.00	.....
22	.....	.....	.....	3.80	6.80	4.60	3.05	3.70	3.05	4.70	3.40	.....
23	[b] 3.20	.....	.....	4.15	6.40	4.80	3.05	3.80	3.00	4.80	3.20	.....
24	.....	.....	.....	4.80	5.90	4.25	3.40	3.00	3.05	4.55	3.25	[l] 3.80
25	.....	.....	.....	5.60	5.55	4.10	3.55	3.00	3.30	4.20	3.15	.....
26	.....	.....	[m] 4.40	5.90	5.90	4.30	3.25	2.85	3.80	3.75	3.20	.....
27	[m] 3.40	[f] 3.70	.....	6.00	5.85	4.35	3.65	2.95	3.80	4.15	3.20	.....
28	[m] 3.40	.....	.....	6.15	5.45	4.40	4.15	3.25	3.80	4.20	3.55	.....
29	.....	.....	.....	7.05	6.20	4.30	3.90	3.50	4.00	3.50	5.10	.....
30	[b] 3.20	.....	.....	8.95	6.30	4.20	3.95	3.40	5.10	3.30	5.75	.....
31	.....	.....	.....	.....	5.90	.....	3.95	3.40	.....	3.20	.....	[n] 5.00

[a] Ice 2.5 feet thick.
[b] Ice 2 feet thick.
[c] River frozen over.
[d] Ice 1.9 feet thick.
[e] Ice 0.35 foot thick.
[f] Ice 1.85 feet thick.
[g] River clear of ice.
[h] Ice 2.8 feet thick.
[i] Ice 2.4 feet thick.
[j] Ice 0.6 foot thick.
[k] Ice 2.7 feet thick.
[l] Ice 0.9 foot thick; gage reading to top of ice = 3.8.
[m] Ice 2.2 feet thick.
[n] Ice 1.8 feet thick; gage reading to top of ice = 5.0.

NOTE.—During frozen season gage readings are to surface of water in hole cut in ice.

Rating table of Kennebec River near North Anson, Me., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.75	2,150	4.0	4,587	5.5	8,360	7.0	12,680
2.8	2,224	4.1	4,825	5.6	8,630	7.2	13,300
2.85	2,302	4.2	5,065	5.7	8,900	7.4	13,920
2.9	2,384	4.3	5,305	5.8	9,170	7.6	14,540
2.95	2,468	4.4	5,545	5.9	9,450	7.8	15,160
3.0	2,554	4.5	5,785	6.0	9,730	8.0	15,780
3.1	2,729	4.6	6,035	6.1	10,020	8.2	16,420
3.2	2,908	4.7	6,285	6.2	10,310	8.4	17,060
3.3	3,091	4.8	6,535	6.3	10,600	8.6	17,700
3.4	3,281	4.9	6,790	6.4	10,890	8.8	18,340
3.5	3,479	5.0	7,050	6.5	11,180	9.0	18,980
3.6	3,685	5.1	7,310	6.6	11,480	9.5	20,630
3.7	3,899	5.2	7,570	6.7	11,780	10.0	22,280
3.8	4,121	5.3	7,830	6.8	12,080	10.5	23,980
3.9	4,351	5.4	8,090	6.9	12,380		

The above table is applicable only for open-channel conditions. It is based upon 13 discharge measurements made during 1901 to 1904, inclusive. It is fairly well defined between gage heights 2 feet and 5 feet. Above gage height 5 feet the curve is somewhat uncertain. The table has been extended beyond these limits.

Estimated monthly discharge of Kennebec River near North Anson, Me., for 1904.

[Drainage area, 2,880 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
April 10–30	22,620	3,791	9,755	3.39	2.65
May	24,660	8,225	13,940	4.84	5.58
June	13,920	4,825	7,783	2.70	3.01
July	8,630	2,641	5,250	1.82	2.10
August	7,050	2,302	4,265	1.48	1.71
September	7,310	2,384	3,747	1.30	1.45
October	8,900	2,462	4,221	1.47	1.70
November	9,035	2,150	3,146	1.09	1.22

KENNEBEC RIVER AT WATERVILLE, ME.

The only long-continued observations of the flow of the river are those which have been made at Waterville by the Hollingsworth & Whitney Company, which kindly furnishes the results for publication.

The works of that company are above the mouth of Sebasticook River. The tributary drainage area of the Kennebec at that point is about 4,380 square miles. Observations are made at 12 o'clock noon of each day, that hour having been chosen, after investigation, as a time when the flow is least affected by storage at dams upstream and as giving most nearly the average for the day.

When the flow of the river is less than 3,500 second-feet, the whole amount is diverted through the water wheels of the mill, of which there are 48. Water in excess of the above amount is wasted over the dam. All of the wheels have been tested at Holyoke under practically the same head as used at Waterville. Discharge curves for the wheels and for overflow of the dam, both with and without flashboards, were constructed several years ago by Mr. Sumner Hollingsworth. Estimates of daily flow are made by means of these diagrams. The leakage through the crib dam has never been measured, but 100 second-feet are added arbitrarily to cover this item.

Mean daily discharge, in second-feet, of Kennebec River at Waterville, Me., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1,313	953	1,018	8,733	34,770	7,532	6,131	5,080	3,514	10,460	4,148	2,908
2	975	918	1,047	7,980	33,910	10,490	5,980	5,168	3,692	7,968	3,908	2,891
3	1,381	917	1,044	6,770	23,890	10,220	4,872	4,086	3,415	6,806	3,649	3,462
4	714	944	1,132	7,211	22,060	8,675	4,140	4,983	3,602	5,960	3,521	1,545
5	896	1,248	1,370	6,777	20,730	10,310	7,370	4,923	5,534	4,183	3,516	3,150
6	552	940	100	8,349	21,970	10,610	6,174	4,508	5,921	4,064	2,689	2,894
7	959	543	659	9,541	18,370	12,740	5,585	3,843	5,458	4,305	3,494	2,783
8	956	940	2,063	15,620	13,390	14,460	5,428	4,817	5,170	3,875	3,486	2,764
9	1,545	629	2,616	23,240	12,810	11,250	5,628	4,378	3,597	3,959	3,573	2,859
10	100	654	2,982	33,340	25,760	13,250	3,423	3,943	4,050	4,045	3,793	2,895
11	830	1,891	3,552	33,530	30,910	12,000	5,442	4,556	2,610	3,828	3,223	100
12	1,218	615	3,291	27,600	37,840	11,190	5,590	4,970	3,779	4,116	3,764	3,183
13	916	713	3,033	23,080	26,850	7,402	7,049	6,273	3,779	4,027	2,659	2,302
14	1,909	100	3,254	14,620	19,610	6,051	8,263	5,247	3,176	4,284	4,096	2,459
15	1,163	645	3,232	12,310	15,510	5,919	6,969	5,687	3,777	4,159	3,512	2,587
16	1,543	1,389	2,799	10,590	28,760	5,801	6,989	5,326	6,978	3,144	4,071	2,323
17	100	538	2,736	8,813	37,560	5,552	3,694	5,087	5,822	4,350	4,365	2,596
18	912	1,432	2,513	8,343	27,440	6,388	5,512	5,419	4,581	4,464	2,875	1,249
19	1,577	578	2,097	7,947	20,680	4,670	5,774	4,918	4,030	4,121	2,898	3,163
20	905	1,393	1,413	8,414	24,520	6,458	4,346	4,261	4,055	4,062	2,678	3,178
21	1,764	100	2,426	10,530	20,910	6,401	4,969	4,380	2,961	3,322	3,755	2,771
22	900	1,081	2,497	10,460	17,880	6,324	4,692	6,720	3,767	5,179	4,078	3,423
23	910	908	3,078	11,110	15,150	5,979	2,941	5,280	4,004	6,866	4,063	2,775
24	308	1,329	3,372	11,740	14,530	5,834	3,987	4,537	3,722	5,722	658	2,899
25	1,012	987	4,064	15,180	13,970	5,579	4,998	3,913	2,691	4,214	4,105	1,966
26	995	1,295	10,470	16,320	13,010	5,110	4,805	4,112	4,082	4,146	2,407	2,074
27	1,642	1,420	11,080	17,810	11,120	7,848	4,699	3,535	4,042	4,816	3,465	3,127
28	638	100	11,880	15,930	11,200	7,251	4,933	2,950	4,381	4,516	2,962	2,833
29	634	651	10,400	20,910	8,277	11,860	5,619	4,256	4,251	3,964	2,353	2,474
30	.629	.....	8,449	36,110	9,031	5,423	5,523	4,152	8,111	2,768	.....	3,048
31	348	.....	8,189	.....	9,774	.....	4,550	4,534	.....	4,139	.....	2,764

MOOSE RIVER NEAR ROCKWOOD, ME.

This station was established September 7, 1902, by N. C. Grover. It is located 4 miles west of Kineo, Me., and 2 miles from the mouth of the river. The drainage basin is 680 square miles at this point. Water is stored by dams at the outlets of several of the lakes and ponds in the basin above, but all of such stored water is used for log driving. The stage of the river changes very slowly after the end of the log-driving season. Practically all of the land areas in this basin are in forest. Measurements are made from a car suspended from a steel cable, or by wading at low water. The initial point for soundings is on the right bank, 1 foot from a birch tree, to which the tag line and cable are attached. There are two gages: One is a painted post driven into the clay bed of the river and braced from several trees; the other is a standard chain gage attached to trees on the bank. The datum of the two gages is the same, and is referred to bench marks as follows: (1) Copper bolt in bowlder 8 feet from corner of house of Peter Callaghan; elevation, 14.58 feet. (2) Highest point of large bowlder on right bank 150 feet below the cable; elevation, 5.75 feet. The channel is about 220 feet wide at ordinary stages and is straight both above and below the station. The banks are high and rocky; the bed of the stream is rocky and permanent. The gage is read twice daily by Peter Callaghan.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Mean daily gage height, in feet, of Moose River near Rockwood, Me., for 1904.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	6.55	4.65	4.00	2.50	2.30	4.70	3.75	2.70
2	.....	6.90	4.60	3.95	2.50	2.35	5.05	3.70	2.60
3	.....	7.15	4.55	4.10	2.50	2.40	5.10	3.60	2.50
4	.....	7.10	4.25	4.20	2.50	2.55	5.10	3.60	2.50
5	.....	7.30	4.25	4.10	2.40	2.85	5.05	3.50	2.50
6	.....	7.55	4.55	4.00	2.30	3.05	5.00	3.50	2.50
7	.....	7.40	4.70	3.85	2.30	3.10	4.90	3.40	2.50
8	.....	7.30	4.95	3.75	2.20	3.10	4.80	3.40	2.40
9	.....	7.25	5.05	3.60	2.20	3.05	4.65	3.30	2.35
10	1.80	7.35	5.00	3.50	2.15	3.00	4.60	3.20	2.30
11	3.15	8.00	5.05	3.45	2.20	3.00	4.50	3.15	.....
12	3.45	9.05	5.25	3.35	2.30	2.95	4.40	3.10	.....
13	3.70	9.10	5.05	3.40	2.30	2.90	4.40	3.10	.....
14	3.85	8.70	4.80	3.35	2.40	2.90	4.35	3.10	.....
15	4.00	8.10	4.65	3.30	2.50	2.95	4.25	3.10	.....
16	4.10	7.90	4.45	3.20	2.50	3.20	4.15	3.10	.....
17	4.15	7.90	4.25	3.15	2.50	3.45	4.05	3.00	.....
18	4.20	7.65	4.10	3.00	2.40	3.50	4.00	2.90	.....
19	4.20	7.25	4.10	2.90	2.40	3.70	3.90	2.90	.....
20	4.20	7.05	.....	2.70	2.45	3.70	3.80	2.90	.....
21	4.30	6.85	.....	2.60	2.50	3.75	3.80	2.90	.....
22	4.30	6.60	.....	2.50	2.65	3.80	3.90	2.90	.....
23	4.30	6.50	4.65	2.40	2.70	3.80	4.00	2.90	.....
24	4.50	6.30	4.65	2.40	2.70	3.80	4.10	2.80	.....
25	4.75	6.00	4.70	2.40	2.70	3.95	4.00	2.80	.....
26	5.05	5.65	4.60	2.40	2.70	4.05	4.00	2.80	.....
27	5.30	5.45	4.55	2.45	2.60	4.20	4.00	2.80	.....
28	5.55	5.30	4.55	2.50	2.50	4.30	3.90	2.80	.....
29	5.85	5.05	4.60	2.50	2.50	4.30	3.90	2.70	.....
30	6.20	5.05	4.20	2.50	2.45	4.50	3.80	2.70	.....
31	.....	4.95	.....	2.50	2.40	.....	3.80	.....	.....

ROACH RIVER AT ROACH RIVER, ME.

This stream, which has a total drainage area of 120 square miles, enters Moosehead Lake from the east. Its basin is completely forested. Dams at the outlets of several ponds control the flow of the river. The gage is located at about 100 feet downstream from the lowest of these dams, at which point the river is so completely under control that the stage does not vary perceptibly for weeks at a time. Impounded water is used for log driving.

This station was established November 10, 1901, by N. C. Grover. The drainage area at this point is 85 square miles. The gage is a vertical rod spiked to the timber retaining wall on the right bank of the stream. It is referred to a bench mark, which is a cross cut in the highest timber of the crib to which the gage is spiked; elevation, 9 feet. Meter measurements of flow are made by wading, or from a boat at a section about 2,000 feet downstream from the gage. The bed of the stream at this point is rocky and permanent. The channel is straight and about 60 feet wide. The gage is read twice daily by C. H. Sawyer.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Mean daily gage height, in feet, of Roach River at Roach River, Me., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	(a)	(a)	(a)	2.30	4.80	2.30	2.30	2.20	2.20	2.30	2.30	2.10
2				2.30	5.30	5.50	2.30	2.20	2.20	2.30	2.20	2.10
3				2.30	5.55	5.50	2.30	2.20	2.20	2.30	2.10	2.10
4				2.30	5.40	5.50	2.30	2.20	2.60	2.30	2.10	(b)
5				2.30	5.40	5.50	2.30	2.20	2.25	2.30	2.10	.....
6				2.30	5.40	5.50	2.30	4.00	2.30	2.30	2.10	.....
7				2.30	5.40	5.50	2.30	3.80	2.30	2.30	2.10	.....
8				2.30	5.40	5.50	2.30	3.00	2.55	2.30	2.10	.....
9				2.30	2.30	3.30	2.30	3.00	2.80	2.30	2.10	.....
10				2.30	2.30	3.30	2.30	3.00	2.80	2.30	2.10	.....
11				2.30	2.30	3.30	2.30	2.60	2.30	2.30	2.10	.....
12				2.30	5.40	3.30	2.30	2.60	2.30	2.30	2.10	.....
13				2.30	5.40	2.50	2.30	3.40	2.30	2.30	2.10	.....
14				2.30	2.30	2.50	2.30	3.40	2.30	2.30	2.10	.....
15				2.30	2.30	2.50	2.30	3.40	2.30	2.30	2.10	.....
16				2.30	2.30	2.50	2.30	2.85	2.30	2.30	2.10	.....
17				2.20	5.50	2.30	2.30	2.30	2.30	2.30	2.10	.....
18				2.20	5.50	2.30	2.60	2.30	2.30	2.30	2.10	.....
19				2.20	2.30	2.30	2.60	2.30	2.30	2.30	2.10	.....
20				2.20	2.30	2.30	2.60	2.30	2.30	2.30	2.10	.....
21				2.20	5.50	2.30	2.60	2.30	2.30	2.55	2.10	.....
22				2.20	5.50	2.30	3.00	2.30	2.30	2.30	2.10	.....
23				2.20	2.30	2.30	2.60	2.70	2.30	2.65	2.10	.....
24				2.20	3.90	2.30	2.20	2.70	2.30	3.00	2.10	.....
25				2.20	3.90	2.30	2.20	2.20	2.30	3.00	2.10	.....
26			2.30	2.20	5.50	2.30	2.20	2.20	2.30	3.00	2.10	.....
27			2.30	2.20	2.30	2.30	2.20	2.20	2.30	3.40	2.10	.....
28			2.30	2.20	5.50	2.30	2.20	2.60	2.30	3.40	2.10	.....
29			2.30	3.30	2.30	2.30	2.20	2.20	2.30	3.40	2.10	.....
30			2.30	4.20	5.50	2.30	2.20	2.20	2.30	3.00	2.10	.....
31			2.30	.....	5.50	.....	2.20	2.20	.....	3.00	.....	.....

a River frozen January 1 to March 25.
b River frozen December 4–31, inclusive.

DEAD RIVER NEAR THE FORKS, ME.

This tributary of the Kennebec has its headwaters in the mountains between Maine and Canada, and flows in a general easterly direction, entering the Kennebec at The Forks. Its basin contains 870 square miles and is 40 miles in extreme length by 30 miles in width, and is almost entirely covered with forests. Through a large portion of its length the river flows through swamps; in its lower course it has considerable fall. The only dams on the stream are owned by the log-driving companies, and the gates are kept open after the drives are out of the river.

This gaging station was established by N. C. Grover on September 29, 1901. It is located 1½ miles west of The Forks. The measurements are made from a car suspended from a steel cable. The gage is a vertical rod attached to a large bowlder on the left bank about 700 feet below the cable. It is referred to a bench mark, a copper bolt set in a bowlder 9.5 feet from the gage; elevation, 7.97 feet above zero of the gage. The channel is straight for 500 feet above and below the cable, and is about 225 feet wide at ordinary stages. The banks are rocky and are subject to overflow in extreme freshets. The bed is rocky and permanent. The current is rapid; the lowest observed mean velocity is 0.65 of a foot per second at gage height 0.69. The gage is read twice daily by Jeremiah Durgin, jr., a farmer at The Forks.

The observations at this station during 1904 have been made under the direction of H. K. Barrow, district hydrographer.

Discharge measurements of Dead River near The Forks, Me., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Square feet.	*Ft. per sec.*	*Feet.*	*Second-feet.*
June 8	F. E. Pressey	900	3.86	3.00	3,470
June 9	do	1,780	8.57	6.35	15,300
June 21	do	444	1.48	1.05	655
June 21	do	453	1.49	1.05	676
July 27	H. K. Barrows	349	.80	.72	279
August 29	do	376	.98	.78	370

Mean daily gage height, in feet, of Dead River near The Forks, Me., for 1904.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	4.15	2.25	1.05	0.95	0.75	2.15	1.35	0.95
2	.....	4.90	2.45	1.20	.95	.75	3.05	1.35	.95
3	.....	5.35	4.15	1.45	.85	.75	3.00	1.35	.95
4	.....	5.40	3.45	1.70	.85	.85	2.70	1.25	1.05
5	4.95	6.85	2.45	1.55	.80	1.25	2.60	1.20	1.05
6	.....	5.25	4.65	1.40	.75	1.45	2.55	1.15	1.15
7	.....	4.55	3.45	1.25	.75	1.30	2.25	1.15	1.15
8	.....	4.45	4.65	1.20	.65	1.20	1.70	1.25	1.15
9	(a)	4.15	4.75	1.00	.65	1.05	1.40	1.25	1.25
10	2.85	4.75	4.50	1.00	.65	1.05	1.35	1.25	1.40
11	2.05	5.15	3.75	1.10	.75	.95	1.25	1.20	(b)
12	3.25	4.55	3.45	1.40	.75	.95	1.25	1.15	.....
13	3.35	4.25	2.60	1.50	.85	1.05	1.15	1.15	.....
14	3.35	4.05	2.10	1.50	.95	1.25	1.25	1.15	.....
15	2.35	5.60	1.80	1.30	.95	1.60	1.15	1.05	.....
16	2.20	4.30	1.50	1.15	.85	1.80	1.15	1.05	.....
17	1.95	4.60	1.40	1.00	.85	1.70	1.25	1.15	.....
18	1.80	4.15	1.20	1.05	.85	1.50	1.15	1.15	.....
19	1.85	6.15	1.05	.95	.85	1.35	1.15	1.05	.....
20	1.85	5.55	1.05	.95	.75	1.45	1.15	1.05	.....
21	1.85	5.65	1.05	.95	1.15	1.35	1.70	1.05	.....
22	1.95	5.45	1.10	.95	1.65	1.35	2.15	1.05	.....
23	2.05	4.80	1.15	.85	1.70	1.35	2.55	1.05	.....
24	2.35	4.65	1.20	.85	1.50	1.25	2.75	1.05	.....
25	2.50	2.85	1.35	.75	1.05	1.25	2.60	1.05	.....
26	3.30	3.05	1.45	.75	.90	1.40	2.40	1.05	.....
27	3.00	5.40	1.45	.65	.80	1.60	1.85	.95	.....
28	3.85	2.90	1.35	.65	.75	1.65	1.65	1.00	.....
29	6.05	4.85	1.20	.75	.75	1.75	1.50	1.00	.....
30	4.45	2.75	1.10	.85	.75	1.85	1.40	.95	.....
31	.....	1.95	.....	.95	.75	.....	1.35	.....	.....

a River clear of ice April 9.
b River frozen over; anchor ice affects gage readings. No readings during frozen period.

CARRABASSETT RIVER AT NORTH ANSON, ME.

This river enters the Kennebec from the west at North Anson. Its basin has steep slopes, partly in farm lands, with no large natural reservoirs. Dams have been constructed and power used at New Portland, East New Portland, and North Anson.

This gaging station was established on October 19, 1901, by N. C. Grover. It is located above Embden Brook and below Anson Brook. The drainage area is 340 square miles at this point. Gagings are made by wading at low stages or from a boat at high stages of the river. There are two gages. One is a vertical rod attached to a tree; the other is a standard chain gage attached to trees on the bank; length of chain, 36.73 feet. The datum of the two gages is the same, and is referred to two bench marks: (1) Point on root of a blazed spruce

tree 40 feet from the vertical gage; elevation, 10.78 feet. (2) Copper bolt set in a large bowlder at the outlet of Anson Brook; elevation, 11.40 feet. The channel is straight 500 feet above the station and 300 feet below, and is about 150 feet wide, divided into two parts at low stages of the river by a gravelly bar. The bed is of coarse gravel and permanent. Observed mean velocities range from 3.35 feet per second at gage height 2.68 feet to 0.93 of a foot per second at gage height 0.60 foot. The gage is read once daily by N. Q. Hilton, a farmer at North Anson.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Carrabassett River at North Anson, Me., 1902–1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
1902.		*Square feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
June 27	N. C. Grover	1,330	3.14	4.30	4,170
July 30	F. E. Pressey	203	.95	.60	192
October 30	do	564	3.21	2.47	1,810
October 30	do	632	3.35	2.67	2,120
October 31	do	458	2.99	1.99	1,370
November 1	do	388	2.91	1.69	1,130
November 2	do	326	2.71	1.42	882
November 1	do	379	2.86	1.60	1,080
November 3	do	314	2.71	1.35	851
1903.					
May 26	N. C. Grover	151	1.38	.45	208
July 17	F. E. Pressey	264	1.33	.90	348
August 15	do	215	1.39	.71	300
September 23	N. C. Grover	42	1.81	.15	76
November 6	F. E. Pressey	94	1.76	.30	165
1904.					
August 30	H. K. Barrows	100	1.54	.40	154

Mean daily gage height, in feet, of Carrabassett River at North Anson, Me., for 1904.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1			7.3	0.9	0.4	0.7	0.3	2.1	1.1	0.8
2			4.9	.9	.8	.7	.3	1.8	1.1	.8
3			4.0	.8	1.0	.6	.3	1.4	1.0	1.0
4	a 1.9		4.2	.8	.9	.5	.5	1.2	1.0	1.1
5			4.4	.8	.6	.4	.7	1.0	1.0	.9
6			3.7	1.1	.6	.4	.5	.9	.8	.8
7			3.8	2.3	.7	.4	.4	.9	.8	1.0
8			2.6	1.8	.5	.4	.4	.8	.8	.8
9			2.4	1.5	.4	.4	.3	.8	.7	.7
10		4.7	9.5	1.3	.3	.4	.3	.8	.8	.7
11		5.2	5.8	1.1	.3	.6	.3	.7	.8	.7
12		4.1	4.6	.9	2.3	1.3	.3	.7	.8	.7
13		3.3	3.5	.8	1.5	1.2	.4	.7	.6	.6
14		2.7	2.9	.7	1.9	.9	.3	.8	.7	.7
15		2.2	2.4	.6	1.4	.9	.9	.8	.9	.6
16		1.9	11.3	.5	1.1	.8	1.9	.8	.8	.7
17		1.6	6.6	.5	.8	.7	1.3	.7	.7	.7
18		1.7	4.1	.5	.7	.6	1.0	.7	.8	.6
19		1.8	3.3	.4	.5	.5	.9	.7	.9	.7
20		2.8	4.4	.4	.4	.4	.9	.6	.9	.7
21		2.5	3.1	.3	.4	2.7	.9	.6	.7	.7
22		2.3	2.5	.3	.3	1.6	.9	.4	1.2	.7
23		2.5	2.2	.5	.3	1.3	.8	2.5	.9	.8
24		3.2	2.0	.5	.2	1.0	.7	1.9	.8	.8
25		3.9	1.7	.4	.3	.8	.5	1.6	.9	.8
26		3.4	1.6	.6	.3	.7	.4	1.4	1.0	.7
27		3.7	1.5	.4	.2	.5	.4	1.9	.9	.8
28		3.4	1.4	.3	.9	.5	.4	1.6	.7	.9
29		4.7	1.3	.1	1.8	.5	.7	1.5	.8	.9
30		7.1	1.2	.2	1.4	.4	2.8	1.3	.8	.9
31			1.0		.9	.4		1.2		.9

a Gage reading to water surface in hole cut in ice at gage; otherwise no readings during frozen season.

Rating table for Carrabassett River at North Anson, Me., from November 1, 1901, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.1	60	1.5	965	2.9	2,325	4.6	4,575
.2	96	1.6	1,050	3.0	2,450	4.8	4,845
.3	135	1.7	1,135	3.1	2,580	5.0	5,115
.4	177	1.8	1,225	3.2	2,710	5.2	5,385
.5	223	1.9	1,315	3.3	2,840	5.4	5,655
.6	272	2.0	1,405	3.4	2,970	5.6	5,925
.7	327	2.1	1,495	3.5	3,100	5.8	6,195
.8	392	2.2	1,585	3.6	3,230	6.0	6,465
.9	464	2.3	1,680	3.7	3,360	6.5	7,140
1.0	542	2.4	1,775	3.8	3,495	7.0	7,815
1.1	625	2.5	1,875	3.9	3,630	8.0	9,165
1.2	710	2.6	1,980	4.0	3,765	9.0	10,515
1.3	795	2.7	2,090	4.2	4,035	10.0	11,865
1.4	880	2.8	2,205	4.4	4,305	11.0	13,215

The above table is applicable only for open-channel conditions. It is based upon 12 discharged measurements made during 1902 to 1904. It is well defined between gage heights 0.2 feet and 2.5 feet. Above 2.5 the curve depends on one measurement at 4.3 feet. The table has been extended beyond these limits. Above 3.7 feet the rating curve is a tangent, the difference being 135 per tenth.

Estimated monthly discharge of Carrabassett River at North Anson, Me., for 1904.

[Drainage area, 340 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
April 10–30	7,950	1,050	2,913	8.57	6.69
May	13,690	542	3,574	10.5	12.1
June	1,680	60	404	1.19	1.33
July	1,680	96	440	1.29	1.49
August	2,090	177	404	1.19	1.37
September	2,205	135	379	1.11	1.24
October	1,875	177	670	1.97	2.27
November	710	272	438	1.29	1.44
December	625	272	384	1.13	1.30

SANDY RIVER NEAR MADISON, ME.

This stream rises near Rangeley Lake, flowing first southeasterly, then in the last third of its course flowing northeasterly into Kennebec River about 2 miles below the village of Madison. It has a total length of about 50 miles, and while there are a few small ponds in its basin, its storage capacity is small, and the flow is quite variable. It resembles very much in this way Carrabassett River—the slopes being usually steep and the fall very rapid throughout the greater part of its course. Comparatively few water-power developments have been made, namely, at New Sharon, Farmington, and at the point described below near Madison.

This station was established March 23, 1904, by F. E. Pressey. It is located at the dam of the Madison Electric Works just over the town line in Stark, but is nearest Madison post-office. The drainage area at this point is about 650 square miles. The dam rests on ledge rock, has a fairly level crest, 341.4 feet in length between vertical abutments. The crest is 1 foot wide on top, sloping from the upstream edge, 4.75 horizontal to 1.25 vertical, while the downstream face of the dam is vertical. The level top is of dressed stone (6-cut), while the remainder is quarry faced, but care has been taken to leave no considerable projection on the approach to the crest. Provision has been made for the installation of flashboards when necessary. The head developed by the dam is about 15 feet, which is used in a power development on the right bank, consisting of a head bay nearly 100 feet long, decreasing in width from 40 to 20 feet at the racks, and one pair of 36-inch McCormick turbines (rated at Holyoke) with complete arrangements for a second pair if found necessary. This plant is owned by the Madison village corporation, and is used for furnishing light and power. The pondage extends back something like 2 miles, but there is no side flowage. When water is more than 3 feet deep on the dam, the crest is increased in length about 87.5 feet by flowing over the wall of the fore bay. The wheels and generators are in operation only during the night, so that the discharge has been based upon a gage height read late in the afternoon just before starting up; and it is believed that the pondage effect has been wholly eliminated in this way.

A plain vertical staff gage was first fastened to the retaining wall of the dam; the elevation of the 100-foot mark at the gage being equal to the elevation of the crest of the masonry dam. This has been superseded, however, by a float gage referred to the same datum and installed through the courtesy and assistance of C. S. Humphreys, C. E., of Madison, engineer in charge. At the same time another float gage

[illegible] Cleveland River at North Assen, Mo., from November 1, [illegible] December 31, 1904.

Gage height.	[illegible]	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Disch[illegible]
Feet.	[illegible]	Feet.	Second-feet.	Feet.	Second-feet.	Feet.	Seco[illegible]
[illegible]	[illegible]	1.5	[illegible]	2.9	2,325	4.6	[illegible]
[illegible]	[illegible]	1.6	1,050	3.0	2,450	4.8	[illegible]
[illegible]	[illegible]	1.7	1,135	3.1	2,580	5.0	[illegible]
[illegible]	[illegible]	1.8	1,225	3.2	2,710	5.2	[illegible]
[illegible]	[illegible]	1.9	1,315	3.3	2,840	5.4	[illegible]
[illegible]	[illegible]	2.0	1,405	3.4	2,970	5.6	[illegible]
[illegible]	[illegible]	2.1	1,495	3.5	3,100	5.8	[illegible]
[illegible]	[illegible]	2.2	1,585	3.6	3,230	6.0	[illegible]
[illegible]	[illegible]	2.3	1,680	3.7	3,380	6.5	[illegible]
[illegible]	[illegible]	2.4	1,775	3.8	3,495	7.0	[illegible]
[illegible]	[illegible]	2.5	1,875	3.9	3,630	8.0	[illegible]
[illegible]	[illegible]	2.6	1,980	4.0	3,765	9.0	[illegible]
[illegible]	[illegible]	2.7	2,090	4.2	4,035	10.0	[illegible]
[illegible]	[illegible]	2.8	2,205	4.4	4,305	11.0	[illegible]

[illegible] is applicable only for open-channel conditions. [illegible] made during 1902 to 1904. It is well [illegible] Above 2.5 the curve depends on [illegible] and 2.5 feet. [illegible] has been extended beyond these limits. [illegible] the difference being 135 per tenth.

[illegible] discharge of Cleveland River at North Assen, [illegible]

[illegible]

[illegible]	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

This [illegible]
then [illegible]
nebec River [illegible]
total length [illegible]
in its basin [illegible]
It resembles [illegible]
being [illegible]
part of [illegible]
have been [illegible]
point [illegible]

This [illegible]
is located [illegible]
town line [illegible]
area [illegible]
rock [illegible]
abutments [illegible]
edge [illegible]
the dam [illegible]
the remainder [illegible]
considerable [illegible]
been made [illegible]
head [illegible]
development [illegible]
feet long [illegible]
pair of [illegible]
arrangement [illegible]
owned [illegible]
light and [illegible]
but there [illegible]
the dam [illegible]
over the wall [illegible]
tion [illegible]
a gage height [illegible]
it is believed [illegible]
this way [illegible]

A plain vertical [illegible]
the dam, the elevation [illegible]
to the elevation [illegible]
[illegible]
through the [illegible]
Madison [illegible]

[illegible]
[illegible]
77
46
54
64
64

to 15
miles,
diner.
linary
tide at
three-
permost
ompany,
al water
Record
the dam
s the yield
have been
years, and
Twombly.

was placed to record the height of water in the tailrace, so that in case it becomes necessary to use the turbines in estimating flow, records of the head on the wheels may be obtained. The gages are referred to the following bench mark: A point inclosed by a circle on the north side of the wing wall, about 22.8 feet from its end at the dam, marked "B. M." Its elevation is 102.98 feet above gage datum. The gages are read twice daily by Marcus W. Moore, electrician at the station.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

MESSALONSKEE RIVER AT WATERVILLE, ME.

This river enters the Kennebec from the west at Waterville. It has a total drainage area of 208 square miles, of which 30 square miles are lake surface. Messalonskee Lake, which is the nearest of these to the mouth of Kennebec River, has a fall of about 210 feet in a distance of 10 miles, which is practically all utilized.

The United States Geological Survey has maintained a gage at the dam of the Chase Manufacturing Company, in Waterville, since June 18, 1903. The drainage area at this point is about 205 square miles. A vertical staff gage is fastened to the wheel pit, just above the dam. The zero of the gage corresponds to the level of the crest of the dam and is referred to a bench mark as follows: Copper bolt in ledge on opposite side of the river from the end of the dam; elevation, 14.51 feet above the crest of the dam. The dam is a new crib, without leakage, and with a good crest. Generally the water is not used for power purposes at night, and the gage is read while the wheels are not running. At other times the amount of water used through the wheels is added to that which flows over the dam. Flashboards are maintained during low stages of the river. The gage is read once a day by Ernest E. Bowie, watchman at the mill.

Observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Mean daily discharge, in second-feet, of Messalonskee River at Waterville, Me., for 1904.

Date.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	408	.....	.....	273	126	105	149	118	118
2	.....	336	.....	.....	314	149	113	118	118	118
3	.....	292	.....	.....	273	134	118	105	113	126
4	.....	360	.....	.....	251	144	96	90	118	77
5	.....	432	.....	.....	229	149	90	96	126	64
6	.....	533	.....	.....	251	157	105	105	105	69
7	.....	559	.....	.....	273	85	113	90	118	64
8	.....	533	.....	408	273	118	118	90	85	59
9	.....	615	.....	383	284	126	118	77	77	77
10	.....	899	.....	314	212	126	126	85	85	90
11	.....	840	.....	292	149	134	77	90	64	64
12	.....	840	.....	336	244	126	77	90	69	77
13	205	870	.....	212	177	134	96	96	85	90
14	360	811	.....	292	251	113	96	90	105	64
15	336	724	.....	251	251	85	118	90	105	64
16	301	642	.....	205	[a]64	118	218	64	90	77
17	284	559	.....	251	105	126	149	64	90	54
18	251	615	.....	212	134	134	118	69	85	64
19	273	642	.....	183	157	126	105	64	85	54
20	230	642	.....	193	134	134	118	85	90	64
21	260	642	.....	205	200	200	105	64	90	41
22	273	.....	.....	193	185	126	90	134	96	54
23	587	.....	.....	177	157	144	85	200	105	41
24	724	.....	.....	273	134	126	90	134	105	41
25	724	.....	.....	251	118	126	90	118	118	105
26	697	.....	.....	229	157	126	96	105	126	90
27	507	.....	.....	244	149	134	64	118	113	77
28	383	.....	.....	244	167	90	69	134	90	46
29	360	.....	.....	251	185	126	105	118	77	54
30	408	.....	.....	251	157	126	90	118	85	64
31	432	.....	.....	.....	105	96	.....	118	.....	64

[a] 12-inch flashboards on from July 16 to December 31, inclusive.

COBBOSSEECONTEE RIVER AT GARDINER, ME.

Cobbosseecontee River drains a group of lakes lying from 5 to 15 miles westerly from Augusta, having areas aggregating 19 square miles, and empties into the Kennebec 6 miles below that city at Gardiner. Its total drainage area is about 240 square miles. From the ordinary surface of Lake Maranacook, one of the upper lakes, to mean tide at the mouth of the river the fall is 206 feet, and in the lower three-fourths of a mile it is said to be 136 feet. From above the uppermost of the 8 dams controlled by the Gardiner Water Power Company, which are in the latter three-fourths of a mile, the municipal water supply for Gardiner is drawn and pumped by water power. Record is kept of the water pumped and of the water that passes the dam through a waste gate. The sum of these quantities represents the yield of the drainage area at the upper dam, records of which have been kept by the Gardiner Water Power Company for a series of years, and have been furnished to the Survey by their engineer, A. H. Twombly.

The record for 1904 is presented in the accompanying table. On Sundays and legal holidays the gates are closed and no water is permitted to run, unless the lakes are full. This is a most remarkable example of the regularity of flow that can be obtained with proper storage.

Mean daily discharge, in second-feet, of Cobbosseecontee River at Gardiner, Me., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	200	180	160	280	2,747	280	280	265	265	265	250	220
2	200	180	160	280	2,497	280	280	265	265	00	250	220
3	00	180	160	00	1,859	280	30	265	265	265	250	220
4	200	180	200	280	725	280	29	265	00	265	250	00
5	200	180	200	280	351	00	280	265	265	265	250	220
6	200	180	00	286	283	280	280	265	265	265	00	220
7	200	00	220	306	280	280	280	00	265	265	220	220
8	200	160	250	286	393	280	280	265	265	265	220	220
9	200	160	250	320	500	280	280	265	265	00	220	220
10	00	160	280	532	956	280	00	265	265	265	220	220
11	200	160	290	618	1,406	280	280	265	00	250	220	00
12	180	160	280	497	2,129	00	280	265	265	250	220	220
13	180	160	186	399	1,699	280	280	265	265	250	00	200
14	180	00	280	270	1,105	280	280	00	265	250	220	180
15	180	160	280	276	362	280	280	265	265	250	220	150
16	180	160	280	276	280	280	280	265	265	00	220	130
17	00	160	280	270	537	280	00	265	265	250	220	125
18	180	130	280	270	670	280	280	265	00	250	220	00
19	180	125	280	270	699	00	280	265	265	250	220	115
20	180	125	00	250	699	280	280	265	265	250	00	115
21	180	00	280	372	699	280	265	00	265	250	220	110
22	180	120	280	462	634	280	265	265	265	250	220	110
23	180	135	280	421	489	280	265	265	265	00	220	100
24	00	150	280	250	415	280	00	265	265	250	00	100
25	180	160	337	331	300	280	265	265	00	250	220	48
26	180	160	494	331	280	00	265	265	265	250	220	48
27	180	160	649	405	280	280	265	265	265	250	00	100
28	180	00	564	565	280	280	265	00	265	250	220	100
29	180	160	529	2,652	00	280	265	265	265	250	220	100
30	180	.....	329	2,747	280	280	265	265	00	200	220	100
31	00	.....	280	.....	280	.....	.....	265	.....	250	.....	100

ANDROSCOGGIN RIVER DRAINAGE BASIN.

Androscoggin River is formed by the junction of Magalloway River and the outlet of the Umbagog-Rangeley lakes near the Maine-New Hampshire boundary line. For about 35 miles it flows southward into the State of New Hampshire, then turns abruptly to the east and flows into the State of Maine, then turns to the south and joins the Kennebec in Merrymeeting Bay. The last fall on the Androscoggin is at Brunswick, Me., above which place the drainage area is 3,470 square miles, about 80 per cent of which is in Maine. The greatest length of the basin is 110 miles, the greatest width 70 miles, while the river itself measures about 200 miles in length from the sources of Magallo-

way River to the coast. The following table gives the drainage areas of the river and of some of its chief tributaries:

Drainage areas of Androscoggin River and principal tributaries.

River.	Locality.	Drainage area.
		Square miles.
Androscoggin	Immediately below junction of Umbagog outlet and Magalloway River, at Errol dam.	1,090
Do	Berlin	1,350
Do	Gorham	1,375
Do	Shelburne	1,500
Do	Rumford Falls	2,090
Do	Dixfield	2,230
Do	Livermore Falls	2,550
Do	Lewiston Falls	2,950
Do	Brunswick	3,470
Umbagog outlet	Immediately above junction with Magalloway River.	590
Magalloway	Mouth	500
Little Androscoggin	do	380

The lower part of the basin is hilly and moderately wooded, while the upper two thirds is broken and mountainous, heavily timbered, and with a gravelly, sandy soil. Granite, gneiss, and mica-schists abound along the main course of the river, with clay slate in the upper part of the basin. The river, like others on the southern slopes of Maine, generally has a rocky bed, particularly where falls occur; has high banks, and is seldom subject to overflow, all of which are features of advantage in the development of water powers. Below Berlin the facilities for rail transportation are excellent. Tide-water navigation extends to the falls at Brunswick.

The United States Geological Survey now maintains gaging stations on this river at Shelburne, N. H., and Dixfield, Me.

In addition to these stations, data on the flow of the Androscoggin River is obtained through private parties, at the following points: Errol dam, N. H.; Gorham, N. H.; and at Rumford Falls, Me.

ANDROSCOGGIN RIVER AT ERROL DAM, NEW HAMPSHIRE.

Four large storage dams are maintained in the Umbagog-Rangeley Lake system. They are located at the outlets of Rangeley, Moosehucmaguntic, Richardson, and Umbagog lakes. Errol dam, at the outlet of Umbagog Lake, is the lowest of the series and is below the mouth of Magalloway River. The other three dams control completely the flow from the basin above Richardson Lake, aggregating 520 square miles in area. Errol dam controls in part the run-off from a total area of 1,090 square miles, which includes the area tributary to Richardson

Lake mentioned above, but its height is not sufficient to store the total freshet flow.

The United States Geological Survey, cooperating with Walter H. Sawyer, agent of the Union Water Power Company, Lewiston, Me., is making a series of measurements of flow through the gates at Errol dam. A continuous record of gate openings is kept and when a sufficient number of measurements have been made to warrant the construction of a rating curve for the gates a continuous record of flow at this point will be available. The results of these measurements are not yet ready for publication.

ANDROSCOGGIN RIVER AT GORHAM, N. H.

During the year 1903 the Berlin Mills Company constructed a tight crib dam in Androscoggin River at Gorham. From November 27, 1903, until the end of the year estimates of discharge were obtained by means of a rectangular notch constructed in the dam, and the records furnished by H. S. Ferguson, engineer for the company. (For which see Water-Supply Paper No. 97.) No records of flow are available for 1904 at this point. Drainage area here is 1,375 square miles.

ANDROSCOGGIN RIVER AT SHELBURNE, N. H.

This station was established May 30, 1903, by N. C. Grover. It is located at the steel highway bridge about one-half mile north of the railway station at Shelburne. The drainage area at this point is 1,500 square miles. A standard chain gage is attached to the guard timber on the downstream side of the bridge; length of chain, 20.66 feet when gage was established. This was changed to 20.72 feet on August 4, 1904, owing to change in flooring of bridge and consequent position of gage. It is referred to bench marks as follows: (1) Marked point on south edge of most westerly cylindrical pier; elevation, 17.82 feet. (2) Marked point on lower chord near gage; elevation, 18.77 feet. (3) Highest point of bowlder near most easterly pier; elevation, 7.14 feet. All elevations refer to the datum of the gage. The initial point for soundings is on the left bank of the river at the end of the inclined end post of the downstream truss. The channel of the river is straight for 500 feet above and 1,000 feet below the station, is about 400 feet wide at ordinary stages, and is broken by two piers. The bed of the river is sandy and usually permanent, but in case of serious obstructions to the channel by ice or logs, noticeable changes take place. The velocity is swift at high stages, but becomes low and poorly distributed, with considerable obliquity, at medium and low water conditions, when measurements are made from a boat at a point about 1,000 feet below the bridge, where an excellent site exists for gaging. The banks on both sides are subject to overflow in extreme freshets. The gage is read twice daily by James Simpson, postmaster at Shelburne.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Androscoggin River at Shelburne, N. H., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Square feet.	*Ft. per sec.*	*Feet.*	*Second-feet.*
April 18	N. C. Grover	1,010	2.00	4.55	2,020
May 12	S. K. Clapp	2,420	4.08	7.65	9,880
May 25	N. C. Grover	1,600	2.61	5.59	4,170
June 15	S. K. Clapp	1,280	1.95	4.72	2,500
July 22	do	953	1.43	3.94	1,360
August 29[a]	F. E. Pressey	650	2.98	4.48	1,940
November 15[a]	do	510	2.35	4.22	1,200

[a] Made from boat.

Mean daily gage height, in feet, of Androscoggin River at Shelburne, N. H., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	.....	.....	6.70	5.10	4.95	4.00	4.40	4.40	4.80	4.65
2	.....	.....	.....	.....	7.55	5.00	5.00	4.00	4.30	4.50	4.70	4.70
3	[a] 6.30	.....	.....	[b] 6.30	8.30	4.95	5.10	4.00	4.35	4.40	4.55	[c] 4.90
4	.....	.....	.....	.....	8.60	4.90	5.05	4.05	4.40	4.40	4.45	.....
5	.....	.....	.....	.....	8.55	4.90	5.10	4.10	4.40	4.40	4.40	.....
6	.....	.....	[d] 6.20	.....	8.50	4.90	5.20	4.00	4.40	4.40	4.35	.....
7	.....	[e] 6.20	.....	.....	8.50	4.95	5.10	4.10	4.40	4.35	4.30	.....
8	.....	.....	.....	.....	8.50	5.00	5.05	4.20	4.40	4.40	4.40	.....
9	.....	.....	.....	[f] 5.25	8.55	4.95	5.00	4.10	4.30	4.40	4.30	.....
10	[g] 6.10	.....	.....	6.35	8.35	4.90	4.95	4.10	4.40	4.50	4.40	.....
11	.....	.....	.....	6.10	8.60	4.90	4.85	4.10	4.40	4.50	4.35	6.25
12	.....	.....	.....	5.35	7.75	4.80	4.85	4.10	4.45	4.50	4.30	.....
13	.....	.....	[h] 6.30	4.90	7.30	4.80	4.70	4.20	4.40	4.40	4.30	[i] 6.30
14	.....	[j] 5.40	.....	4.40	6.80	4.70	4.65	4.35	4.40	4.45	4.35	.....
15	.....	.....	.....	4.50	6.75	4.60	4.35	4.40	4.40	4.50	4.35	.....
16	.....	.....	.....	4.45	7.00	4.60	4.25	4.40	4.40	4.40	4.20	.....
17	[k] 6.30	.....	.....	4.45	7.85	4.50	4.35	4.30	4.40	4.50	4.20	.....
18	.....	.....	.....	4.60	7.55	4.60	4.40	4.20	4.45	4.40	4.20	.....
19	.....	.....	.....	4.70	7.60	4.60	4.15	4.15	4.50	4.40	4.20	[l] 6.40
20	.....	.....	[m] 6.70	4.80	7.50	4.60	4.20	4.20	4.50	4.50	4.30	.....
21	.....	[n] 5.20	.....	4.60	6.70	4.50	4.05	4.20	4.40	5.00	4.30	.....
22	.....	.....	.....	4.60	6.25	4.60	4.00	4.15	4.45	5.00	4.20	.....
23	.....	.....	.....	4.70	6.05	4.55	3.95	4.00	4.45	4.75	4.20	.....
24	[o] 6.10	.....	.....	5.00	5.90	4.60	4.05	4.10	4.40	4.65	4.20	.....
25	.....	.....	.....	5.70	5.70	4.65	4.00	4.10	4.50	4.55	4.20	[p] 6.30
26	.....	.....	.....	5.70	5.60	4.70	4.10	4.10	4.50	4.70	4.20	.....
27	.....	.....	[k] 8.50	5.50	5.30	4.70	4.00	4.10	4.50	5.05	4.15	.....
28	.....	[e] 6.40	.....	5.80	5.35	4.75	3.95	4.20	4.50	5.10	4.10	.....
29	.....	.....	.....	7.05	5.20	4.80	3.95	4.30	4.45	4.95	4.20	.....
30	.....	.....	.....	6.85	5.10	4.85	4.05	4.30	4.50	4.95	4.30	.....
31	[q] 6.40	.....	.....	.....	5.10	.....	4.10	4.40	.....	4.80	.....	.....

[a] Ice 1.25 feet thick.
[b] Ice 1.85 feet thick.
[c] Frozen over.
[d] Ice 2.9 feet thick.
[e] Ice 3.5 feet thick.
[f] Ice went out during night.
[g] Ice 1.9 feet thick.
[h] Ice 2.85 feet thick.
[i] Ice 2.1 feet thick.
[j] Ice 4.1 feet thick.
[k] Ice 2.5 feet thick.
[l] Ice 2.2 feet thick.
[m] Ice 2.7 feet thick.
[n] Ice 4.35 feet thick.
[o] Ice 2.75 feet thick.
[p] Gage height to top of ice=6.55; ice 2.1 feet thick.
[q] Ice 3.1 feet thick.

NOTE.—Gage heights during frozen season are to surface of water in hole cut in ice under gage.

ANDROSCOGGIN RIVER AT RUMFORD FALLS, ME.

One of the finest water powers in the Atlantic Coast drainage is at Rumford Falls. Here the Androscoggin descends 177 feet in 1 mile in several pitches over granite ledges. A comprehensive plan of development has been laid out and partly executed. It contemplates the use of power from three levels—a high-level canal, with a fall of 97 feet to the middle level, which receives also a direct and independent supply of water from the river. The water in the middle-level canal is then used and discharged after a fall of 50 feet into the low level, from which in turn there is a final drop of 30 feet to the river. Dams have been built at the entrance of the high and middle level canals. At present about 19,000-horsepower are utilized, largely in the manufacture of pulp and paper. An economical development of the entire fall of 177 feet would furnish 50,000 horsepower. This power is 85 miles by rail from Portland, and for pulp and paper manufacture has the advantage of excellent transportation facilities. Androscoggin River is used for floating down pulp wood and timber from the headwaters to the mills, and the Rumford Falls and Rangeley Lakes Railroad, extending into the forests with its extension into the Megantic region, makes available the remoter resources of spruce, poplar, and birch.

The discharge of Androscoggin River at Rumford Falls since 1892 has been computed by Charles A. Mixer, resident engineer of the Rumford Falls Power Company. These statistics are obtained by adding the actual measured quantities passing through the wheels to the computed flow over the dam, using the customary Francis weir formula with modified coefficient. They have been published from time to time by the United States Geological Survey, and a complete record up to 1902 will be found in Water-Supply Paper No. 69.

ANDROSCOGGIN RIVER NEAR DIXFIELD, ME.

This station was established August 22, 1902, by F. E. Pressey. It is located about one-half mile west of Dixfield, at the highway bridge on the road to West Peru. The measurements are made from this bridge or from a boat at low water. The initial point for soundings is at the lower end of the inclined end post of the downstream truss on the left bank of the river. The gage is of the standard chain type; the scale board is nailed to the guard timber on the lower side of the bridge; length of chain, 31.76 feet. It is referred to bench marks as follows: (1) Southeast corner of bridge seat on north abutment; elevation, 24.77 feet. (2) Copper bolt in ledge under east end of bridge; elevation, 11.53 feet. (3) Top of short post at west hanger in east span; elevation, 33.15 feet when gage was established; found to be 33.08 feet on August 3, 1904; probably due to settlement of post. All elevations refer to the datum of the gage. The channel is straight for 1,000 feet above and one-half mile below the station, and is about 600 feet wide, broken by three piers. The banks are high

and not liable to overflow. The bed of the stream is rocky in the left half and sandy in the right half. The velocity is medium at high stages, but is poorly distributed at low water, when the current is sluggish in the right half. Under such conditions measurements are made from the bridge for only the two left-hand portions of the channel, while the remaining part is gaged by wading at a point about 250 feet downstream—it being possible to do this on account of a sandy bar separating these two parts. The gage is read twice daily by S. F. Robinson.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurement of Androscoggin River near Dixfield, Me., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Square feet.	*Ft. per sec.*	*Feet.*	*Second-feet.*
August 3	H. K. Barrows	1,200	1.31	7.68	1,570

Mean daily gage height, in feet, of Androscoggin River near Dixfield, Me., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	.....	8.85	12.95	8.80	8.60	7.80	7.55	8.55	8.25	7.90
2	a 9.60	.....	b 9.40	8.65	12.45	8.75	8.85	7.85	7.45	8.45	8.10	8.00
3	.....	c 9.20	.....	8.70	12.30	8.70	8.95	7.75	7.50	8.20	8.00	7.70
4	.....	.....	.....	8.65	12.45	8.60	8.85	7.85	7.70	8.15	7.95	7.65
5	.....	.....	.....	8.50	12.30	8.65	8.90	7.75	7.60	8.05	8.00	7.80
6	.....	c 9.20	.....	8.90	12.15	8.75	8.85	7.70	7.30	7.90	7.90	8.10
7	d 9.60	.....	.....	9.30	11.65	8.95	8.55	7.65	7.60	7.95	7.90	8.10
8	.....	.....	b 9.85	9.25	11.55	8.95	8.20	7.50	7.60	8.00	8.00	8.50
9	.....	.....	.....	10.00	11.45	8.90	8.15	7.55	7.55	7.90	7.90	9.10
10	.....	.....	.....	11.20	12.25	8.80	8.10	7.65	7.45	7.90	7.95	10.00
11	d 9.70	c 9.10	b10.30	12.00	12.10	8.75	8.00	7.65	7.55	8.05	7.95	.....
12	.....	.....	.....	10.95	11.80	8.75	8.10	7.65	7.40	8.00	8.00	.....
13	d 9.70	.....	.....	10.20	11.10	8.70	8.15	7.75	7.60	7.95	8.00	.....
14	d 9.00	.....	.....	9.55	10.65	8.70	8.05	7.80	7.70	8.00	7.95	.....
15	.....	c 9.10	b10.10	9.10	10.30	8.70	7.90	7.50	8.40	7.95	7.85	e 9.40
16	f 9.50	.....	.....	9.05	11.00	8.60	7.95	7.75	9.15	7.95	8.05	.....
17	.....	.....	b 9.70	8.80	12.05	8.65	7.85	7.70	8.50	7.65	7.90	.....
18	.....	c 9.10	.....	8.85	11.60	8.60	7.70	7.60	8.00	8.00	7.75	.....
19	.....	.....	.....	9.05	11.50	8.50	7.80	7.55	7.55	7.90	7.90	.....
20	g 9.50	.....	.....	9.50	12.35	8.55	7.70	7.60	7.55	7.85	7.75	.....
21	.....	.....	.....	9.25	11.30	8.55	7.60	9.05	7.85	7.85	7.85	.....
22	.....	h 9.20	.....	9.20	10.45	8.55	7.55	8.50	8.20	11.05	7.95	.....
23	.....	.....	i 9.20	9.45	10.10	8.60	7.45	8.25	8.05	9.45	7.95	.....
24	e 9.40	.....	.....	9.90	9.95	8.60	7.70	8.00	7.90	8.60	8.00	j10.00
25	.....	.....	.....	10.55	9.65	8.50	7.80	7.90	7.90	8.60	8.05	.....
26	.....	.....	k 9.60	10.85	9.50	8.60	7.95	7.80	7.90	8.65	8.00	.....
27	.....	i 9.40	12.25	10.70	9.40	8.55	8.20	7.70	8.25	9.00	7.90	.....
28	.....	.....	11.85	10.60	9.25	8.55	8.20	7.70	8.00	8.85	7.90	.....
29	.....	.....	10.10	12.25	9.10	8.50	8.35	7.50	7.90	8.60	7.90	.....
30	c 9.20	.....	9.15	13.65	8.95	8.45	8.25	7.55	8.40	8.40	7.85	.....
31	.....	.....	8.80	.....	8.85	.....	7.80	7.60	.....	8.10	.....	f 9.90

a Ice 0.9 foot. b Ice 1.8 feet. c Ice 1.5 feet. d Ice 1.2 feet. e Ice 0.7 foot. f Ice 1.3 feet. g Ice 1.4 feet. h Ice 1.7 feet. i Ice 1.6 feet. j Ice 1.1 feet. k Channel cut through at 2 p. m.

PRESUMPSCOT RIVER DRAINAGE BASIN.

This is one of the most interesting as well as one of the best water-power streams of its size in the United States. It is the outlet of Sebago Lake, which lies about 17 miles northwest of Portland. The lake is fed by Crooked River, a stream heading 35 miles farther north and within 3 miles of the Androscoggin. The area of the lake is 50 square miles, the area of its drainage basin at the outlet of the lake 420 square miles, and the total drainage area of the river at its mouth 600 square miles. The northern part of the basin is mountainous and wooded, while the southern part is moderately hilly and cleared of trees. Granite, gneiss, and mica schists appear at many points, and the soil is gravelly and sandy.

According to the survey made by Joseph A. Warren, of Cumberland Mills, the fall from the crest of the stone dam at the foot of Sebago Lake to mean low tide at the foot of the lower falls is 265.16 feet in a distance of 21.65 miles, or an average of 12.25 feet per mile. In the lower two-thirds of this distance, or from Gambo Falls to tide water, nearly one-half of the whole fall, or 132 feet, has been developed, and an aggregate probably exceeding 6,000 net horsepower is in use. The remainder of the fall, however, between Gambo Falls and Sebago Lake, amounting to 133 feet, is either unimproved or but slightly utilized. At Great Falls, in this stretch, there is a descent of 22 feet, which has been used in the past but is now idle. It is proposed, however, to employ the power in the generation of electricity for delivery in Portland.

The tributaries of Presumpscot River are not of much importance, but some of them are outlets of ponds and have considerable fall, thus affording constant though small power. Crooked River, the chief feeder of Sebago Lake, has a number of falls, some of which are utilized.

The chief interest attaching to the river is its regularity of flow, which is due to dams at the outlet of the lake. Nowhere in the United States is there a better example of the success of storage of water and regulation of the flow of a stream than on the Presumpscot.

PRESUMPSCOT RIVER AT OUTLET OF SEBAGO LAKE, MAINE.

Since January, 1887, the flow from Sebago Lake has been regularly recorded, the quantity being deduced from the openings in the gates at the dam, the discharging capacity of which under different conditions of head has been determined and tabulated by Hiram F. Mills, of Lowell. Since January, 1872, a continuous record of the level of the lake surface has been kept. An unusually complete and valuable series of data has thus been obtained, which has been furnished to the United States Geological Survey by S. D. Warren & Co. The lake fills rap-

idly after March 1, attaining its maximum height between April 15 and June 1, and then gradually subsides as water is withdrawn for mill purposes, until a minimum stage is reached, sometimes in the autumn, but usually in the winter. The records of the daily discharge of the river at the outlet of the lake, published in Water-Supply Paper No. 69, show the remarkable uniformity of flow, which, as already stated, is due largely to artificial regulation. On Sundays the gates are closed, so that only the waste is allowed to reach the river.

Mean daily discharge, in second-feet, of Presumpscot River at outlet of Sebago Lake, Maine, for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	678	500	370	589	333	712	724	640	757	642	688	660
2	678	500	450	604	638	786	719	627	745	338	694	647
3	617	500	440	300	627	728	333	627	734	705	694	642
4	617	500	430	552	644	687	367	618	333	681	687	358
5	617	500	437	601	648	333	687	630	767	673	698	625
6	617	500	417	581	627	701	675	753	747	676	500	656
7	617	450	437	571	709	720	675	333	722	653	761	635
8	617	450	435	596	333	728	680	633	725	647	687	665
9	617	450	422	587	673	727	658	642	795	333	687	552
10	583	450	452	300	720	718	333	629	570	668	670	648
11	583	450	468	524	730	731	628	617	333	682	682	360
12	583	450	447	581	722	333	674	609	787	685	687	603
13	583	450	250	595	734	713	702	601	745	668	705	602
14	583	417	472	560	599	739	700	333	645	670	667	593
15	583	417	522	622	333	742	701	598	632	683	765	583
16	583	417	566	669	769	743	659	578	653	333	702	582
17	533	417	563	300	720	743	333	641	648	708	700	567
18	533	417	531	601	695	706	678	640	333	663	688	322
19	533	417	537	658	694	333	641	635	718	670	690	567
20	533	333	250	501	684	753	645	639	632	673	358	570
21	533	250	524	663	688	693	614	333	615	622	655	570
22	533	325	594	648	333	718	604	615	656	653	673	537
23	533	375	623	650	675	694	526	635	658	333	675	540
24	500	393	569	333	682	673	333	650	688	698	677	533
25	500	427	437	680	680	696	658	792	333	665	697	475
26	500	417	504	664	702	333	696	763	770	679	603	470
27	500	377	300	681	703	655	690	600	683	668	358	495
28	500	417	443	662	789	694	648	333	660	668	718	537
29	500	388	498	631	0	657	619	655	649	635	653	443
30	500	.....	562	583	79	661	608	805	663	333	655	500
31	.....	.....	581	.....	586	.....	333	780	.....	677	.....	502

SACO RIVER DRAINAGE BASIN.

This river receives its headwaters from the valleys and slopes of the White Mountains at elevations of 4,000 to 5,000 feet. It drains an area of 1,720 square miles, of which 900 square miles lie in New Hampshire and the remainder in Maine. The slopes at the headwaters are very steep, with no lake storage. In the lower river are many good water powers, part of which are in use. The upper por-

tions of the basin are generally in forest, but much of the large growth has been cut, and over large areas the evergreen trees have been entirely removed. In the lower basin are many farms and villages. The underlying rock is generally granite, appearing at the surface in many mountain summits.

SACO RIVER NEAR CENTER CONWAY, N. H.

This station was established August 26, 1903, by N. C. Grover. It is located at the wooden highway bridge between Center Conway and Redstone, about 2 miles from each place. The drainage basin at this point has an area of 385 square miles. A standard chain gage is attached to the floor of the bridge; length of chain, 30.44 feet. It is referred to bench marks as follows: (1) Marked point on lower chord of bridge near gage; elevation, 27.72 feet. (2) South end of top of west abutment; elevation, 25.14 feet. The channel is straight for 2,000 feet above and 300 feet below the station, and is about 200 feet wide at ordinary stages, broken by one pier. The banks are high and are not liable to overflow, except in very extreme freshets. The bed is of sand and gravel and is permanent. At low water the observed mean velocity is small, being 1.18 feet per second at gage height 4.3. Low-water measurements are usually made by wading about 400 feet above the bridge, where a mean velocity of 1.22 feet per second was observed at gage height 3.92. The gage is read twice daily by Albert P. Davidson.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Saco River near Center Conway, N. H., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.			*Square feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
Aug. 26	H. K. Barrows	167	429	1.18	4.31	504
27[a]	do	277	294	1.30	4.13	382
Sept. 19[a]	do	275	295	1.22	3.92	359
1904.						
Apr. 19	N. C. Grover	227	738	2.20	5.87	1,623
May 2	S. K. Clapp	251	1,477	3.88	9.00	5,730
13	do	235	986	2.83	7.00	2,786
26	N. C. Grover	224	740	2.12	5.76	1,567
June 14	S. K. Clapp	144	417	1.17	4.11	488
July 21[a]	do	230	119	1.27	3.39	151
Aug. 9	do	200	141	1.31	3.45	185
Oct. 11[a]	T. W. Norcross	280	320	1.14	3.88	365
11[a]	do	280	321	1.14	3.92	366

[a] At wading section.

Mean daily gage height, in feet, of Saco River near Center Conway, N. H., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	.....	5.75	9.90	4.70	4.10	3.45	3.38	5.46	4.36	.....
2	.....	.....	.....	5.50	9.22	4.65	4.38	3.46	3.37	4.94	4.62	.....
3	7.10	.....	.....	5.55	8.60	4.58	4.18	3.56	3.37	4.68	4.30	.....
4	.....	.....	.....	5.30	8.82	4.52	3.98	3.67	3.82	4.50	4.25	.....
5	.....	.....	.....	5.28	9.02	4.52	3.84	3.60	3.76	4.26	4.14	.....
6	.....	.....	[a] 7.50	5.75	8.48	4.68	3.78	3.54	3.54	4.19	4.15	.....
7	6.10	.....	.....	6.18	7.72	4.72	3.74	3.52	3.45	4.26	4.15	.....
8	.....	.....	.....	5.98	7.72	4.61	3.66	3.45	3.41	3.98	4.10	.....
9	.....	.....	.....	7.10	7.58	4.47	3.62	3.42	3.37	3.94	4.00	.....
10	[b] 7.00	.....	.....	9.70	8.85	4.38	3.58	3.42	3.41	3.93	3.95	.....
11	.....	.....	.....	8.68	9.10	4.28	3.57	3.44	3.36	4.04	3.95	(c)
12	.....	.....	.....	7.75	7.68	4.20	3.60	3.48	3.32	3.89	3.90	.....
13	.....	.....	(c)	7.08	7.04	4.15	3.70	3.46	3.32	3.89	3.85	.....
14	.....	[d] 6.40	.....	6.60	6.68	4.12	3.62	3.47	3.26	3.57	4.05	.....
15	.....	.....	.....	6.20	7.10	4.07	3.58	3.44	5.34	3.86	4.05	.....
16	.....	.....	.....	6.05	8.94	4.05	3.54	3.44	5.43	3.85	4.00	.....
17	[e] 7.00	.....	.....	5.70	8.06	3.58	3.45	3.42	4.41	3.92	3.95	.....
18	.....	.....	.....	5.70	7.58	3.92	3.46	3.42	4.05	3.92	3.75	[f] 4.25
19	.....	.....	.....	5.82	9.24	3.84	3.42	3.35	3.90	3.83	(g)	.....
20	.....	.....	(c)	6.20	9.58	3.83	3.42	3.54	3.86	3.88	(g)	.....
21	.....	[d] 6.20	.....	5.88	7.78	3.75	3.40	6.18	3.92	8.13	4.1	.....
22	.....	.....	.....	5.72	6.98	3.88	3.88	4.48	4.05	5.86	4.2	.....
23	.....	.....	.....	5.94	6.16	3.95	3.38	4.04	3.68	5.86	4.1	.....
24	[h] 7.00	.....	.....	6.35	6.28	3.83	3.40	3.62	3.76	5.25	4.1	.....
25	.....	.....	.....	7.20	6.01	3.75	3.46	3.72	4.75	4.92	4.0	[i] 4.30
26	.....	.....	.....	7.90	5.78	3.70	3.52	3.63	4.34	5.12	3.9	.....
27	.....	.....	(c)	7.75	5.58	3.70	3.56	3.56	4.20	4.90	4.0	.....
28	.....	[d] 6.70	.....	7.78	5.35	3.65	3.74	3.54	4.42	4.56	4.1	.....
29	.....	.....	.....	10.02	5.01	3.71	3.58	3.48	4.00	4.49	(g)	.....
30	.....	.....	.....	10.82	4.91	3.70	3.51	3.44	5.88	4.45	.....	.....
31	[h] 6.75	.....	{[f] 7.15 / 6.52}	.....	4.75	.....	3.48	3.42	.....	4.46	.....	.....

[a] Ice 2.50 feet.
[b] Ice 1.25 feet.
[c] Ice unsafe to go upon.
[d] Ice 2 feet.
[e] Ice 1.35 feet.
[f] Gage height to top ice=4.5 feet—ice 1.15 feet thick.
[g] Frozen over.
[h] Ice 1.50 feet.
[i] Gage height to top ice=4.3 feet—ice 1.13 feet thick.
[j] Morning and evening readings.

NOTE.—Gage heights during frozen season are to surface of water in hole in ice under gage.

Rating table of Saco River near Center Conway, N. H., from August 27, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.25	117	4.2	475	5.9	1,675	8.2	4,420
3.3	133	4.3	525	6.0	1,765	8.4	4,740
3.35	149	4.4	575	6.1	1.855	8.6	5,060
3.4	166	4.5	625	6.2	1,950	8.8	5,390
3.45	183	4.6	675	6.3	2,050	9.0	5,730
3.5	200	4.7	730	6.4	2,150	9.2	6,080
3.55	217	4.8	795	6.5	2,250	9.4	6,440
3.6	235	4.9	865	6.6	2,350	9.6	6,800
3.65	253	5.0	935	6.7	2,460	9.8	7,175
3.7	271	5.1	1,005	6.8	2,570	10.0	7,555
3.75	289	5.2	1,080	6.9	2,680	10.2	7,935
3.8	307	5.3	1,160	7.0	2,790	10.4	8,315
3.85	325	5.4	1,240	7.2	3,030	10.6	8,710
3.9	343	5.5	1,320	7.4	3,280	10.8	9,110
3.95	361	5.6	1,405	7.6	3,545		
4.0	380	5.7	1,495	7.8	3,825		
4.1	425	5.8	1,585	8.0	4,120		

The above table is applicable only for open-channel conditions. It is based upon discharge measurements made during 1903 and 1904. It is well defined between gage heights 3.40 feet and 9 feet. The table has been extended beyond these limits.

Estimated monthly discharge of Saco River near Center Conway, N. H., for 1903 and 1904.

[Drainage area, 385 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1903.					
August 26–31	530	350	402	1.04	0.23
September	405	193	264	.69	.77
October	2,270	200	550	1.43	1.65
November 1–26	465	239	339	.88	.85
1904.					
April	9,110	1,160	2,815	7.31	8.16
May	7,365	760	3,682	9.56	11.02
June	742	228	451	1.17	1.31
July	565	159	250	.65	.75
August	1,930	149	276	.72	.83
September	1,657	120	411	1.07	1.19
October	4,345	224	754	1.96	2.26
November 1–18	685	289	424	1.10	.735

MERRIMAC RIVER DRAINAGE BASIN.

This basin, which has a total drainage area of 5,015 square miles, lies in the States of New Hampshire and Massachusetts; of this, 3,815 square miles are in the former State and 1,200 square miles in the latter. Merrimac River is formed at Franklin, N. H., by the junction of Pemigewasset and Winnepesaukee rivers. The headwaters of the Pemigewasset lie in the White Mountain region at elevations of approximately 2,000 feet; thence they flow southerly through New Hampshire with very steep slopes. On this branch of the Merrimac there is very little lake storage. Squam and New Found lakes, aggregating about 20 square miles of surface area, are the only bodies of water of any importance. Above Plymouth probably 85 per cent of the basin is in heavy forest. A very insignificant amount of water power is utilized. Winnepesaukee River has its headwaters in the eastern part of the State. A prominent characteristic of its basin is the extent of the lake surface, aggregating 100 square miles. The fall from Winnepesaukee Lake to the junction with Pemigewasset River is 225 feet in a distance of 14 miles.[a]

From Franklin Merrimac River flows southerly through the State of New Hampshire for 56 miles, receiving Contoocook River from the west and Suncook River from the east. After entering Massachusetts the river deflects to the east and flows in an easterly and northeasterly direction, a distance of 40 miles, to Newburyport, where it enters an arm of the sea. Tide flows to Lawrence.

The United States Geological Survey maintains gaging stations in this basin on Merrimac River at Franklin Junction; on Pemigewasset River at Plymouth; on Contoocook River at West Hopkinton, and on Suncook River at East Pembroke.

In addition, data of flow are furnished the Survey by private parties or corporations for Merrimac River at Garvins Falls, near Concord, N. H.; Merrimac River at Lawrence; Sudbury River at Framingham; Lake Cochituate at Cochituate, Mass., and the South Branch of Nashua River at Clinton, Mass.

[a] Tenth Census, vol. 16, p. 50.

Drainage areas of Merrimac River and some of its principal tributaries are given in the following table:

Drainage area of Merrimac River and tributaries.

River.	Locality.	Drainage area.
		Sq. miles.
Merrimac	Mouth	5,015
Do	Lawrence dam	4,664
Do	Lowell dam	4,127
Do	Garvins Falls	2,340
Do	Franklin Junction	1,460
Pemigewasset	Plymouth	615
Do	Junction with Winnepesaukee	1,085
Winnepesaukee	Junction with Pemigewasset	435
Contoocook	West Hopkinton	410
Do	Mouth	750
Suncook	East Pembroke	250
Do	Mouth	270

MERRIMAC RIVER AT FRANKLIN JUNCTION, N. H.

This station was established July 8, 1903, by H. K. Barrows. It is located at the wooden railway bridge near Franklin Junction, about a mile below the union of Pemigewasset and Winnepesaukee rivers. The drainage area at this point is 1,460 square miles. A standard chain gage is fastened to the guard timber of the bridge; length of chain, 47.08 feet. It is referenced by bench marks as follows: (1) Marked point on lower chord near gage; elevation, 46.54 feet. (2) Top of north rail at west portal of bridge; elevation, 47.08 feet. (3) Spike in telegraph pole nearest west end of bridge; elevation, 46.38 feet. (4) Top of northwest nut on guard timber; elevation, 47.28 feet. All elevations refer to the datum of the gage. The initial point for soundings is at the top of the face of the right abutment at the upstream side of the bridge. The channel is straight above and below the bridge and is about 200 feet wide at ordinary stages, broken by one pier. The banks are high and rocky and not subject to overflow. The bed is rocky and permanent. The current is swift, having an observed mean velocity of 1.53 feet per second at a gage height of 4.20, the lowest measurement made. The gage is read twice daily by F. R. Roers.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Merrimac River at Franklin Junction, N. H., in 1903 and 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Square feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
July 13	H. K. Barrows	805	1.84	4.46	1,480
July 14	do	768	1.85	4.42	1,420
July 31	do	840	1.93	4.66	1,620
September 5	do	840	2.00	4.67	1,680
September 9	do	745	1.53	4.20	1,140
October 8	N. C. Grover	724	1.48	4.17	1,070
1904.					
April 6	N. C. Grover	1,250	4.31	6.83	5,400
April 21	S. K. Clapp	1,260	3.96	6.46	4,990
May 4	do	1,830	5.46	8.92	9,990
May 24	N. C. Grover	1,285	4.15	6.88	5,330
June 8	S. K. Clapp	1,020	3.10	5.47	3,170
July 7	do	812	2.09	4.51	1,700
September 23	T. W. Norcross	790	2.03	4.66	1,600
November 8	do	855	1.79	4.50	1,530

Mean daily gage height, in feet, of Merrimac River at Franklin Junction, N. H., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.70	.....	.....	7.75	12.90	5.30	4.50	4.40	4.10	7.00	4.85	4.00
2	4.80	.....	.....	7.15	10.10	5.20	4.90	4.40	4.20	5.70	4.80	4.00
3	4.70	.....	.....	6.10	8.90	5.20	4.55	4.40	4.10	5.60	4.70	3.90
4	(a)	.....	.....	6.30	8.80	5.20	4.50	4.35	3.90	5.45	4.70	3.60
5	.....	.....	.....	6.15	8.60	4.80	4.50	4.40	4.20	5.30	4.60	3.90
6	.....	.....	.....	6.90	8.45	5.35	4.40	4.50	4.30	5.10	4.30	4.00
7	.....	.....	.....	7.90	7.45	5.50	4.40	3.95	4.25	4.90	4.40	4.10
8	.....	.....	.....	7.90	6.70	5.45	4.40	4.50	4.20	4.70	4.45	4.20
9	.....	.....	.....	9.40	7.05	5.40	4.40	4.30	4.20	4.10	4.40	4.10
10	.....	.....	.....	11.50	7.00	5.20	3.90	4.30	4.15	4.60	4.40	4.10
11	.....	.....	.....	10.65	7.00	5.05	4.25	4.35	4.10	4.80	4.30	4.45
12	.....	.....	.....	8.35	6.90	4.90	4.30	4.40	4.10	4.70	4.30	4.80
13	.....	.....	.....	7.90	6.70	5.10	4.20	4.50	4.20	4.80	4.30	4.50
14	.....	.....	.....	7.10	6.70	4.80	4.25	3.90	4.20	4.80	4.30	4.30
15	.....	.....	5.50	6.55	6.60	4.60	4.30	4.10	5.00	4.75	4.40	4.40
16	.....	.....	5.50	6.30	7.90	4.60	4.20	4.15	7.05	4.20	4.40	4.40
17	.....	.....	5.10	6.30	11.40	4.60	3.70	4.10	5.55	4.40	4.40	4.40
18	.....	.....	5.10	6.10	10.40	4.50	4.10	4.10	4.55	4.50	4.30	(a)
19	.....	.....	4.70	6.15	7.90	4.35	4.15	4.05	4.60	4.60	4.20	.....
20	.....	.....	4.15	6.20	12.50	4.30	4.10	4.25	4.60	4.60	4.05	.....
21	.....	.....	4.50	6.30	9.80	4.25	4.20	7.60	4.70	4.70	4.20	.....
22	.....	.....	4.45	6.40	7.20	4.30	4.20	5.90	4.90	7.85	4.40	.....
23	.....	.....	4.70	6.55	7.30	4.30	4.10	5.65	4.75	.....	4.35	.....
24	.....	.....	5.80	6.70	6.85	4.35	3.75	5.70	4.50	.....	4.30	.....
25	.....	.....	6.30	7.65	6.20	4.20	3.95	5.10	3.95	.....	4.30	.....
26	.....	.....	7.10	8.70	6.30	4.15	4.10	4.40	5.80	.....	4.30	.....
27	.....	.....	8.10	8.55	6.25	4.10	4.20	4.40	5.45	.....	3.60	.....
28	.....	.....	9.10	10.10	5.90	4.10	4.40	3.75	5.20	.....	4.00	.....
29	.....	.....	7.80	12.30	5.30	4.20	4.45	4.05	5.20	.....	3.95	.....
30	.....	.....	7.70	13.45	5.50	4.30	4.30	4.15	7.70	.....	3.90	.....
31	.....	.....	7.70	.....	5.50	.....	3.75	4.10	.....	.....	.....	.....

(a) River frozen from January 4 to March 15 and from December 18 to 31.

Rating table for Merrimac River at Franklin Junction, N. H., from July 8, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.6	460	4.9	2,065	6.2	4,310	8.6	9,265
3.7	570	5.0	2,220	6.3	4,500	8.8	9,715
3.8	680	5.1	2,380	6.4	4,690	9.0	10,170
3.9	795	5.2	2,540	6.6	5,070	9.5	11,320
4.0	910	5.3	2,705	6.8	5,460	10.0	12,470
4.1	1,030	5.4	2,875	7.0	5,850	10.5	13,670
4.2	1,150	5.5	3,045	7.2	6,250	11.0	14,870
4.3	1,270	5.6	3,220	7.4	6,660	11.5	16,080
4.4	1,395	5.7	3,395	7.6	7,075	12.0	17,330
4.5	1,520	5.8	3,575	7.8	7,500	12.5	18,580
4.6	1,645	5.9	3,755	8.0	7,930		
4.7	1,775	6.0	3,940	8.2	8,370		
4.8	1,915	6.1	4,125	8.4	8,815		

The above table is applicable only for open-channel conditions. It is based upon 14 discharge measurements made during 1903 and 1904. It is well defined between gage heights 4.15 feet and 8.90 feet. The table has been extended beyond these limits.

Estimated monthly discharge of Merrimac River at Franklin Junction, N. H., for 1903 and 1904.

[Drainage area, 1,460 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1903.					
July 9–31	3,431	703	1,676	1.15	0.894
August	2,909	795	1,475	1.01	1.16
September	1,482	350	1,007	.690	.770
October	2,380	150	1,345	.921	1.06
November	1,710	680	1,155	.791	.882
December	4,348	680	1,412	.967	1.11
1904.					
March 15–31	10,400	1,090	4,307	2.95	1.86
April	20,950	4,125	7,825	5.36	5.98
May	19,580	2,705	7,754	5.31	6.12
June	3,045	1,030	1,866	1.28	1.43
July	2,065	570	1,203	.824	.950
August	7,075	625	1,650	1.13	1.30
September	7,285	795	1,951	1.34	1.50
October 1–22	7,608	1,030	2,415	1.65	1.35
November	1,990	460	1,312	.899	1.00
December 1–17	1,915	460	1,139	.780	.493

MERRIMAC RIVER AT GARVINS FALLS, NEW HAMPSHIRE.

A new stone masonry dam was completed at Garvins Falls, on Merrimac River, during the spring of 1904. The drainage area at this point is about 2,340 square miles. This dam was built by the Manchester Traction, Light and Power Company. It has a total length of about 550 feet, and is somewhat similar in section to the dam at Holyoke, Mass. Very careful records of the pond and tailrace levels, wheel openings, etc., are kept here, and will be furnished to the United States Geological Survey. The average head on wheels is about 29 feet.

During 1904 a number of current-meter measurements have been made by the United States Geological Survey for the purpose of rating the turbines and to assist in computing flow over the dam. The publication of estimates of flow at this point is withheld awaiting confirmation of data.

MERRIMAC RIVER AT LAWRENCE, MASS.

Records of flow of this river at Lawrence have been kept for more than fifty years, but have never been published in full. Figures for the monthly maximum and minimum discharges from 1890 to 1897 were published in the Nineteenth Annual Report, Part IV; the daily discharge for 1897, 1898, and 1899 in Water-Supply Paper No. 35; the daily discharge for 1900 in Water-Supply Paper No. 47; the daily discharge for 1901 and 1902 in Water-Supply Paper No. 82; for 1903 in Water-Supply Paper No. 97. These figures are furnished by R. A. Hale, principal assistant engineer of the Essex Water Power Company.

For a portion of the year water from the Sudbury and Nashua River drainage basins is wasted into the Merrimac, and therefore the drainage area is a somewhat variable quantity. During the dry months a very small amount is received. The following tables give the flow of the Merrimac at Lawrence, also the quantity wasted from the Sudbury and Nashua River drainage basins that reaches the Merrimac. The latter table is based on data furnished by the Metropolitan Water and Sewerage Board of Boston. The drainage areas are as follows:

Drainage areas in Merrimac River basin.

	Sq. miles.
Total of Merrimac River drainage basin above Lawrence	4,664
Nashua River drainage basin above gaging station	119
Sudbury River drainage basin, Framingham, Dam No. 1	75
Cochituate River drainage basin	19
Total of Nashua, Sudbury, and Cochituate River drainage basins	213
Net drainage basin of Merrimac River, excluding Nashua, Sudbury, and Cochituate River basins	4,451

The quantity as measured at Lawrence includes the water from Sudbury, Nashua, and Cochituate rivers, and in getting the absolute yield

of the river this should be considered in reference to the drainage areas, either by deducting it from the Merrimac flow and using the net area of the Merrimac and the net flow of the Merrimac, or by getting the total yield of both the Sudbury and Nashua rivers with the Merrimac and using the total area.

Flow of Merrimac River at Lawrence, Mass., for 1904.

[Cubic feet per second for twenty-four hours.]

Day.	Quantity of water passing—					
	January.	February.	March.	April.	May.	June.
1	2,825	4,039	4,034	17,994	46,336	6,252
2	2,265	3,115	3,828	21,175	38,498	5,241
3	1,901	3,041	3,949	23,976	29,795	6,233
4	4,265	2,854	4,274	22,677	22,895	5,574
5	2,796	2,812	3,667	19,056	20,321	5,431
6	2,753	2,109	4,373	17,218	18,408	6,292
7	2,644	1,242	6,085	17,726	16,477	6,583
8	2,724	3,801	6,730	19,432	13,731	8,287
9	1,904	3,152	10,627	20,738	13,193	8,368
10	1,298	2,896	13,740	28,174	13,244	7,520
11	3,852	2,869	14,711	36,984	14,560	6,298
12	2,901	2,813	13,406	33,942	17,567	5,269
13	2,878	1,852	11,664	27,748	17,469	5,921
14	2,798	1,017	10,881	22,937	13,795	5,115
15	3,059	3,728	9,728	19,028	11,340	4,465
16	2,095	2,965	8,831	16,369	11,657	4,175
17	1,613	2,873	7,883	14,613	15,507	3,921
18	3,936	2,660	7,353	14,544	19,890	2,748
19	3,042	2,737	6,668	14,624	16,912	2,862
20	2,769	1,909	6,817	15,183	21,331	4,193
21	2,920	899	8,714	14,449	27,354	3,592
22	2,820	3,679	9,198	14,355	22,002	2,914
23	1,753	3,364	9,500	13,300	17,542	2,911
24	1,062	3,394	11,360	12,254	14,211	2,946
25	3,621	3,592	14,370	12,684	11,326	1,918
26	2,869	4,129	23,479	13,620	10,999	1,805
27	2,832	3,392	35,149	15,139	10,508	4,002
28	2,875	3,397	36,205	20,584	9,431	3,024
29	2,914	5,043	31,579	35,300	8,496	3,017
30	2,241	.....	23,660	45,300	7,704	3,132
31	1,681	.....	19,408	.....	7,721	.....
Total	81,906	85,373	381,871	621,123	540,220	140,009
Average	2,642	2,944	12,318	20,704	17,426	4,667

Flow of Merrimac River at Lawrence, Mass., for 1904—Continued.

Day.	Quantity of water passing—					
	July.	August.	September.	October.	November.	December.
1	3,236	3,230	2,271	4,759	3,084	2,606
2	3,516	2,681	2,254	5,205	3,086	2,500
3	5,193	2,321	1,643	5,457	3,063	1,659
4	4,586	2,651	393	4,359	3,181	390
5	5,174	2,647	409	3,977	2,112	2,640
6	4,575	1,799	3,378	3,623	1,656	2,434
7	3,795	327	2,844	3,213	3,813	2,469
8	3,340	3,163	2,370	2,128	3,006	2,498
9	2,496	2,850	2,301	1,377	2,795	2,031
10	2,302	2,620	1,546	3,923	2,567	1,392
11	4,225	2,382	358	3,131	2,667	289
12	2,881	2,529	2,303	2,973	1,702	2,255
13	2,783	1,578	2,275	2,798	431	2,028
14	2,716	288	2,295	3,067	3,656	2,018
15	2,713	3,065	2,586	2,124	3,293	2,033
16	1,667	2,850	3,396	1,946	3,107	1,977
17	928	2,445	7,983	4,023	3,070	1,153
18	3,758	2,549	5,595	3,031	2,858	177
19	2,714	2,495	5,526	2,925	2,131	1,775
20	2,662	1,550	4,423	2,780	1,049	1,886
21	2,638	393	3,397	2,933	3,629	1,978
22	2,403	5,267	3,156	2,076	3,094	1,962
23	1,384	5,819	3,121	6,130	3,055	1,861
24	367	4,494	2,003	6,808	1,096	1,164
25	2,601	3,468	1,601	5,330	4,010	154
26	2,680	3,489	3,942	4,607	2,632	302
27	2,397	1,927	3,142	4,002	1,649	2,462
28	2,485	767	3,887	3,894	3,697	2,705
29	2,579	3,487	3,504	3,075	3,173	3,017
30	1,661	2,402	3,486	2,674	2,540	3,022
31	260	2,298	.....	4,364	.....	1,541
Total	86,715	79,831	87,388	112,712	80,902	56,378
Average	2,797	2,575	2,913	3,636	2,697	1,819

Average weekly flow of Merrimac River at Lawrence, Mass., for 1904.

Week ending Sunday—	Merrimac River at Lawrence (total drainage area = 4,664 square miles).	Wasting into Merrimac from—				Net yield of Merrimac River from 4,452 square miles.	
		Nashua River at Clinton (drainage area = 118 square miles).	Sudbury River at Dam 1 (drainage area = 75 square miles).	Lake Cochituate, Bonnister Brook (drainage area = 19 square miles).	Total waste of those watersheds (total drainage area = 212 square miles).	Cubic feet per second.	
	Cubic feet per second for seven days.					Seven days.	Per square mile.
December 25...	1,540	3	2	0	5	1,535	0.345
December 18...	1,663	3	2	0	5	1,658	.372
September 11..	1,887	3	2	0	5	1,882	.423
January 1, 1905.	1,929	3	2	0	5	1,924	.432
December 11...	1,965	3	2	0	5	1,960	.440
July 31.....	2,095	3	11	0	14	2,081	.467
September 4 ...	2,107	3	12	0	15	2,092	.470
August 21.....	2,192	3	20	0	23	2,169	.487
August 14.....	2,201	3	16	0	19	2,182	.490
August 7.....	2,237	4	14	0	18	2,219	.498
July 24.....	2,275	3	12	0	15	2,260	.508
December 4....	2,366	4	2	0	6	2,360	.530
November 13...	2,426	4	3	0	7	2,419	.543
February 21 ...	2,539	4	62	0	66	2,473	.556
July 17.....	2,559	3	14	0	17	2,542	.571
January 24.....	2,615	3	39	0	42	2,573	.578
January 10.....	2,626	4	25	0	29	2,597	.583
February 14....	2,629	4	54	0	58	2,571	.578
January 31.....	2,719	4	53	0	57	2,662	.598
November 20...	2,738	4	3	0	7	2,731	.613
November 27...	2,738	3	2	0	5	2,733	.614
January 17.....	2,742	4	34	0	38	2,704	.607
February 7.....	2,745	3	51	0	54	2,691	.604
October 16.....	2,852	4	2	0	6	2,846	.639
June 26.....	2,897	8	18	4	30	2,867	.644
November 6....	2,935	4	7	0	11	2,924	.657
September 25 ..	3,318	3	2	0	5	3,313	.744
October 23.....	3,414	4	2	0	6	3,408	.766
October 9.....	3,448	3	2	0	5	3,443	.773
February 28 ...	3,564	4	117	0	121	3,443	.773
July 3.....	3,589	6	22	0	28	3,561	.800
August 28	3,604	3	32	0	35	3,569	.802
July 10.....	3,753	3	22	0	25	3,728	.837
September 18 ..	3,776	4	2	0	6	3,770	.847
October 2.....	3,989	3	2	0	5	3,984	.895
March 6.....	4,167	4	112	0	116	4,051	.910
June 19.....	4,172	11	29	2	42	4,130	.928
October 30.....	4,341	3	2	0	5	4,336	.974
June 5.....	6,308	5	64	12	81	6,227	1.398

Average weekly flow of Merrimac River at Lawrence, Mass., for 1904—Continued.

Week ending Sunday—	Merrimac River at Lawrence (total drainage area = 4,664 square miles).	Wasting into Merrimac from—				Net yield of Merrimac River from 4,452 square miles.	
		Nashua River at Clinton (drainage area = 118 square miles).	Sudbury River at Dam 1 (drainage area = 75 square miles).	Lake Cochituate, Bonnister Brook (drainage area = 19 square miles).	Total waste of those watersheds (total drainage area = 212 square miles).	Cubic feet per second.	
	Cubic feet per second for seven days.					Seven days.	Per square mile.
1904.							
June 12	6,945	99	77	15	191	6,754	1.517
March 20	8,309	7	151	0	158	8,151	1.831
March 13	10,995	8	303	0	311	10,684	2.400
May 29	11,788	23	39	14	76	11,712	2.631
April 24	14,101	38	142	19	199	13,902	3.123
May 15	14,453	171	222	45	438	14,015	3.148
March 27	15,967	8	248	0	256	15,711	3.529
May 22	19,236	113	123	32	268	18,968	4.261
April 10	20,717	179	323	100	602	20,115	4.519
May 8	22,875	115	285	17	417	22,458	5.044
April 17	24,517	397	236	112	745	23,772	5.340
April 3	24,857	12	195	33	240	24,617	5.530
May 1	26,995	813	617	76	1,506	25,489	5.725
Total, 52 weeks	335,415	2,133	3,835	481	6,449	328,966	73.892
Weekly average	6,450	41	74	9	124	6,326	1.421

PEMIGEWASSET RIVER AT PLYMOUTH, N. H.

This station was established September 5, 1903, by N. C. Grover. It is located at the wooden highway bridge, below the mouth of Bakers River, in the town of Plymouth. The drainage area at this point is about 615 square miles. The headwaters of the river lie in the mountainous country to the west of Mount Washington, at elevations of more than 2,000 feet. At North Woodstock Pemigewasset River is formed by the junction of East Branch, Middle Branch, and Moosilauke Brook, at an elevation of about 700 feet. Thence the waters flow south, receiving Mad River from the east and Bakers River from the west, until at Plymouth, about 20 miles below North Woodstock, the elevation is between 400 and 500 feet. The underlying rock in this basin is usually granite, exposed in the mountain summits. The basin contains some of the best spruce standing in New England. Large areas in the basin of East Branch are still in virgin forest; other areas have been practically stripped, especially on Hancock Brook, a tributary of East Branch, and in the basin of Middle Branch.

The height of water at Plymouth has been recorded daily since January 1, 1886, during which time extensive deforestation in the basin

above has taken place. This record of gage height has been kindly given to the United States Geological Survey by Locks and Canals Company, of Lowell, Mass. From these the daily discharge of the river since that date has been estimated from measurements of flow at the station during 1903 and 1904.

A standard chain gage is attached to the guard rail of the sidewalk of the bridge on the upstream side; length of chain, 34.69 feet. It is referred to bench marks as follows: (1) Marked point on rail of bridge near gage; elevation, 34.00 feet. (2) North corner of intermediate cast-iron gage set by Locks and Canals Company, of Lowell, Mass.; elevation, 13.27 feet. (3) North corner of lowest cast-iron gage set by same company; elevation, 7.11 feet. All elevations refer to the datum of the gage. The initial point for soundings is at the top of the face of the right abutment on the upstream side. The channel is straight for 1,000 feet above and below the bridge, and is about 180 feet wide at ordinary stages, broken by one pier. The banks are high and rocky. The bed is permanent; rocky in the right half and gravelly in the left. The velocity is rapid in the right and sluggish in the left half. At low water the measurements of flow through the left channel are made by wading. The lowest observed mean velocity is one foot per second. The gage is read twice daily by Frank Morton.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Pemigewasset River at Plymouth, N. H., in 1903 and 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Square feet.*	*Ft. per. sec.*	*Feet.*	*Second-feet.*
September 5...	N. C. Grover.....	250	1.08	1.85	270
September 22..	H. K. Barrows.....	238	1.00	1.74	238
October 9.....	N. C. Grover.....	243	1.17	1.98	285
1904.					
April 14.....	N. C. Grover.....	931	2.88	4.75	2,680
April 14.....	.....do	920	2.80	4.70	2,580
April 20.....	S. K. Clapp.....	836	2.70	4.34	2,257
April 30.....	.....do	2,043	5.65	10.36	12,800
May 21.....	.....do	1,360	4.17	6.75	5,675
May 25.....	N. C. Grover.....	782	2.55	4.06	2,000
June 9,.....	.....do	559	1.86	3.02	1,042
July 5.....	S. K. Clapp.....	288	1.45	2.12	419
July 26.....	.....do	197	.91	1.55	179
August 5.....	.....do	278	1.61	2.11	448
August 23.....	H. K. Barrows.....	630	2.03	3.15	1,280
September 23..	S. K. Clapp.....	350	1.84	2.47	642
October 14.....	T. W. Norcross.....	399	1.81	2.65	722
November 22...	.....do	356	1.73	2.54	616

Mean daily gage height, in feet, of Pemigewasset River at Plymouth, N. H., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.20	[a] 3.90	.....	.....	8.85	2.85	2.05	1.78	1.82	5.55	2.82	2.20
2	5.15	.....	.....	6.70	7.85	2.80	3.00	1.88	1.90	4.55	2.72	2.20
3	.....	.....	.....	.....	6.88	2.62	3.00	1.98	1.72	3.90	2.70	2.20
4	[b] 4.75	.....	[c] 4.65	.....	7.12	2.48	2.55	2.48	2.20	3.50	2.62	1.75
5	.....	[a] 3.65	.....	[d] 6.12	7.30	2.40	2.10	1.98	2.35	3.20	2.55	2.20
6	.....	.....	.....	3.42	6.75	2.72	2.06	1.98	1.90	3.05	2.50	1.90
7	.....	.....	[c] 4.60	5.80	5.80	2.98	2.01	1.80	1.90	2.90	2.50	2.00
8	[f] 3.90	[a] 4.25	.....	5.50	6.00	3.20	1.85	1.82	1.88	2.88	2.40	2.00
9	.....	.....	[c] 8.60	7.20	5.68	3.15	1.88	1.72	1.80	2.70	2.35	1.95
10	.....	.....	.....	9.40	6.45	2.78	1.80	1.70	1.80	2.75	2.20	2.05
11	[g] 4.20	.....	.....	7.88	8.25	2.55	1.78	1.70	1.45	2.82	2.15	1.95
12	.....	[c] 3.30	[i] 6.70	6.45	6.45	2.35	1.72	2.10	1.80	2.95	2.20	2.00
13	.....	.....	.....	5.55	5.28	2.32	1.82	2.05	1.62	2.82	2.10	1.80
14	.....	.....	[i] 6.65	4.78	4.82	2.25	1.92	1.85	1.62	2.88	2.40	2.00
15	[f] 4.40	[c] 4.10	.....	4.48	4.70	2.15	1.82	1.80	4.65	2.72	2.10	1.90
16	.....	.....	.....	4.18	8.02	2.00	1.72	2.00	4.82	2.60	2.20	1.90
17	.....	.....	.....	3.95	9.90	1.88	1.70	1.98	3.40	2.50	2.00	2.00
18	[f] 4.30	.....	.....	3.80	6.28	1.95	1.62	1.92	2.95	2.35	2.15	1.90
19	.....	[c] 4.15	[k] 4.30	4.05	6.82	1.90	1.68	1.90	2.60	2.50	2.15	2.10
20	.....	.....	.....	4.28	9.50	1.90	1.60	2.30	2.50	2.35	2.20	2.05
21	.....	.....	.....	3.92	6.62	1.95	1.62	6.62	2.80	3.20	2.35	2.05
22	[f] 4.10	[c] 4.20	[h] 5.10	3.92	5.40	2.00	1.58	3.80	2.85	7.88	2.60	1.90
23	.....	.....	.....	4.32	4.75	2.12	1.52	3.22	2.48	5.60	2.40	1.90
24	.....	.....	.....	5.25	4.35	2.00	1.45	2.85	2.40	3.88	2.20	2.05
25	[f] 4.20	.....	.....	6.70	3.98	1.98	1.58	2.50	5.30	3.42	2.20	2.20
26	.....	.....	8.30	7.52	3.80	1.95	1.58	2.32	3.75	3.85	2.30	2.10
27	.....	[c] 4.50	12.45	7.28	3.48	1.90	1.98	2.20	3.72	4.28	2.45	2.15
28	.....	.....	.....	7.82	3.42	1.88	2.50	2.00	3.20	3.62	2.45	2.30
29	[f] 4.30	[c] 4.55	10.00	8.88	3.30	1.92	2.05	1.90	3.00	3.25	2.40	2.30
30	.....	.....	.....	9.68	3.08	1.98	2.32	1.85	7.22	3.15	2.30	2.30
31	.....	.....	8.40	.....	2.95	.....	1.85	1.85	.....	2.98	.....	2.25

[a] Ice 1.65 feet.
[b] Ice 1.4 feet.
[c] Ice 1.7 feet.
[d] Ice went out.
[e] Ice 1.8 feet.
[f] Ice 1.5 feet.
[g] Ice 1.55 feet.
[h] Ice 2.2 feet.
[i] Ice 2.8 feet.
[j] Ice 1.6 feet.
[k] Ice 2.3 feet.

NOTE.—Gage heights during frozen season are to surface of water in hole cut in ice under gage.

Rating table for Pemigewasset River at Plymouth, N. H., from September 5, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.25	117	2.7	780	4.9	2,860	8.2	8,370
1.3	124	2.8	860	5.0	2,980	8.4	8,770
1.35	132	2.9	940	5.1	3,100	8.6	9,170
1.4	140	3.0	1,020	5.2	3,220	8.8	9,570
1.45	149	3.1	1,110	5.3	3,350	9.0	9,970
1.5	160	3.2	1,200	5.4	3,480	9.2	10,370
1.55	172	3.3	1,290	5.5	3,620	9.4	10,790
1.6	185	3.4	1,380	5.6	3,770	9.6	11,210
1.65	200	3.5	1,470	5.7	3,920	9.8	11,630
1.7	215	3.6	1,560	5.8	4,080	10.0	12,050
1.75	232	3.7	1,650	5.9	4,240	10.5	13,100
1.8	250	3.8	1,740	6.0	4,400	11.0	14,150
1.85	270	3.9	1,830	6.2	4,720	11.5	15,200
1.9	290	4.0	1,920	6.4	5,060	12.0	16,250
1.95	315	4.1	2,020	6.6	5,400	12.5	17,300
2.0	340	4.2	2,120	6.8	5,750	13.0	18,350
2.1	395	4.3	2,220	7.0	6,110	14.0	20,450
2.2	455	4.4	2,320	7.2	6,470	15.0	22,550
2.3	515	4.5	2,420	7.4	6,830	16.0	24,650
2.4	575	4.6	2,530	7.6	7,210	17.0	26,750
2.5	640	4.7	2,640	7.8	7,590	18.0	28,850
2.6	710	4.8	2,750	8.0	7,970		

NOTE.—This table has been applied back to January 1, 1886, as no discharge measurements were made previous to 1903.

The above table is applicable only for open-channel conditions. It is based upon 15 discharge measurements made during 1903 and 1904. It is well defined between gage heights 1.6 and 6.7 feet. Above 6.7 feet the curve depends on one measurement at 10.3 feet. The table has been extended beyond these limits. Above gage height 9.2 feet the rating curve is a tangent, the difference being 210 per tenth.

Estimated monthly discharge of Pemigewasset River at Plymouth, N. H., 1886–1904.

[Drainage area, 615 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1886.					
April 15–30	13,310	2,805	7,247	11.78	6.57
May	4,975	1,182	2,334	3.80	4.38
June	2,350	593	1,085	1.76	1.96
July	1,713	395	551	.896	1.04
August	1,407	305	475	.772	.890
September	2,896	185	540	.878	.980
October	2,070	350	653	1.06	1.22
November 1–15	3,770	964	1,828	2.97	1.66
1887.					
April 15–30	15,720	2,717	7,295	11.86	6.62
May	16,460	2,190	6,871	11.17	12.88
June	20,450	766	3,006	4.89	5.46
July	8,970	766	2,002	3.26	3.76
August	2,020	593	1,040	1.69	1.95
September	900	350	565	.919	1.03
October	1,263	350	473	.769	.887
November 1–15	497	350	413	.672	.372
1888.					
April 15–30	22,760	1,858	5,309	8.64	4.82
May	20,140	3,415	8,756	14.24	16.42
June	5,400	350	1,867	3.04	3.39
July	1,632	350	697	1.13	1.30
August	2,020	305	684	1.11	1.28
September	7,685	350	1,816	2.95	3.29
October	6,290	1,335	2,729	4.44	5.12
November 1–15	7,020	1,857	3,066	4.99	2.78
1889.					
April 15–30	8,870	2,350	5,315	8.64	4.82
May	7,400	964	2,092	3.40	3.92
June	11,210	654	2,183	3.55	3.96
July	7,495	545	1,700	2.76	3.18
August	7,875	350	1,362	2.21	2.55
September	7,020	239	1,077	1.75	1.95
October	8,670	654	2,018	3.28	3.78
November 1–15	2,190	1,110	1,548	2.52	1.40

Estimated monthly discharge of Pemigewasset River at Plymouth, N. H., 1886–1904—Continued.

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1890.					
April 15–30	8,970	3,620	5,714	9.29	5.18
May	17,510	2,270	6,619	10.76	12.41
June	3,770	710	1,690	2.75	3.07
July	7,495	395	1,154	1.88	2.17
August	10,680	270	1,671	2.72	3.14
September	15,410	900	3,302	5.37	5.99
October	7,210	964	2,101	3.42	3.94
November 1–15	1,857	1,110	1,360	2.21	1.24
1891.					
April 15–30	15,410	3,100	8,380	13.63	7.60
May	4,560	1,335	2,705	4.40	5.07
June	2,350	493	1,190	1.93	2.15
July	3,415	305	783	1.27	1.46
August	3,100	270	809	1.32	1.52
September	1,335	185	515	.837	.934
October	593	165	234	.380	.438
November 1–15	1,940	145	421	.685	.382
1892.					
April 15–30	2,618	900	1,467	2.39	1.33
May	7,020	1,407	3,277	5.33	6.13
June	10,170	497	2,290	3.72	4.15
July	9,670	270	1,695	2.76	3.18
August	6,290	185	1,211	1.97	2.27
September	9,670	350	1,029	1.67	1.86
October	710	327	466	.755	.870
November 1–15	3,920	545	1,385	2.25	1.25
1893.					
April 15–30	5,230	2,020	2,923	4.75	2.65
May	17,200	1,488	7,117	11.57	13.34
June	2,805	395	958	1.56	1.74
July	395	165	241	.392	.452
August	6,925	165	692	1.13	1.30
September	1,560	270	619	1.01	1.13
October	6,925	270	1,648	2.68	3.09
November 1–15	1,785	497	864	1.41	.787

Estimated monthly discharge of Pemigewasset River at Plymouth, N. H., 1886–1904—Continued.

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1894.					
April 15–30	18,560	2,805	6,513	10.59	5.91
May	14,680	654	2,519	4.10	4.73
June	6,290	497	1,380	2.24	2.50
July	766	165	419	.681	.785
August	270	145	170	.276	.318
September	4,400	145	598	.972	1.08
October	2,530	209	635	1.03	1.19
November 1–15	4,560	545	1,337	2.17	1.21
1895.					
April 15–30	13,730	3,415	6,432	10.46	5.84
May	6,290	710	2,313	3.76	4.33
June	1,785	395	845	1.37	1.53
July	710	209	388	.631	.728
August	1,182	239	469	.763	.880
September	710	185	294	.478	.533
October	2,190	305	677	1.10	1.27
November 1–15	5,400	545	1,457	2.37	1.32
1896.					
April 15–30	18,560	2,530	7,986	12.99	7.25
May	2,618	593	1,358	2.21	2.55
June	1,632	239	716	1.16	1.29
July	3,285	185	497	.808	.932
August	1,335	239	493	.802	.925
September	6,290	270	1,298	2.11	2.35
October	11,210	545	1,738	2.83	3.26
November 1–15	19,610	900	3,560	5.79	3.23
1897.					
April 15–30	13,840	3,220	7,497	12.19	6.80
May	22,240	1,335	4,085	6.64	7.66
June	13,420	900	2,658	4.32	4.83
July	30,640	654	3,878	6.31	7.27
August	1,335	395	698	1.13	1.30
September	443	185	259	.421	.470
October	2,530	165	363	.590	.680
November 1–15	5,840	209	1,493	2.43	1.36

Estimated monthly discharge of Pemigewasset River at Plymouth, N. H., 1886–1904—Continued.

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1898.					
April 15–30	11,420	3,100	5,395	8.77	4.89
May	14,360	2,020	3,460	5.63	6.49
June	4,160	710	1,517	2.47	2.76
July	654	156	290	.472	.544
August	766	145	302	.491	.566
September	1,182	145	341	.554	.618
October	7,685	270	1,122	1.82	2.11
November 1–15	2,340	654	1,147	1.87	1.04
1899.					
April 15–30	14,880	4,805	9,448	15.36	8.57
May	16,140	964	3,680	5.98	6.89
June	1,182	239	458	.745	.831
July	836	185	317	.516	.595
August	497	132	197	.320	.369
September	836	120	193	.315	.351
October	2,270	132	307	.499	.575
November 1–15	3,220	185	788	1.28	.713
1900.					
April 15–30	19,610	4,000	9,870	16.05	9.25
May	13,000	1,560	3,953	6.42	7.40
June	6,470	209	900	1.46	1.63
July	1,110	185	263	.428	.493
August	900	147	250	.407	.469
September	710	134	215	.350	.390
October	3,770	209	730	1.19	1.37
November 1–15	7,685	239	1,866	3.03	1.69
1901.					
April 15–30	12,780	4,160	6,706	10.90	6.08
May	12,260	1,713	3,895	6.33	7.30
June	2,896	395	1,170	1.90	2.12
July	2,530	270	571	.928	1.07
August	6,290	270	1,016	1.65	1.90
September	395	185	259	.421	.470
October	3,770	209	660	1.07	1.23
November 1–15	710	239	361	.587	.327

Estimated monthly discharge of Pemigewasset River at Plymouth, N. H., 1886–1904—Continued.

Month.	Discharge in second feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
April 15–30	6,290	1,940	3,266	5.31	2.96
May	12,260	305	3,377	5.49	6.33
June	6,290	1,110	2,044	3.32	3.70
July	3,220	710	1,431	2.33	2.69
August	1,335	365	696	1.13	1.30
September	4,560	305	1,128	1.83	2.04
October	18,560	766	2,538	4.13	4.76
November 1–15	2,350	1,110	1,617	2.63	1.47
1903.					
April 15–30	3,100	350	1,729	2.81	1.56
May	3,620	395	1,285	2.09	2.41
June	10,900	350	2,099	3.41	3.80
July	2,896	310	725	1.18	1.36
August	2,190	443	758	1.23	1.42
September	497	144	264	.429	.479
October	1,605	149	486	.790	.911
November	710	215	412	.670	.748
December 1–20	940	215	376	.611	.454
1904.					
April 5–30	11,420	1,398	4,607	7.49	7.24
May	11,840	980	4,741	7.71	8.89
June	1,200	282	537	.873	.974
July	1,020	149	338	.550	.634
August	5,400	215	594	.966	1.11
September	6,470	149	1,045	1.70	1.90
October	7,780	545	1,522	2.47	2.85
November	876	340	554	.901	1.01
December	515	232	372	.605	.698

CONTOOCOOK RIVER AT WEST HOPKINTON, N. H.

This station was established July 9, 1903, by H. K. Barrows. It is located at the wooden highway bridge near the railway station at West Hopkinton. The drainage area at this point is 410 square miles. A standard chain gage is attached to the downstream side of the board covering of the bridge; length of chain, 26.11 feet. It is referred to

a bench mark on the highest point of the large rock on the south side of the road, 15 feet northwest of left abutment; elevation, 21.55 feet above gage datum. The initial point for soundings is at the downstream side of the left abutment at the top. The channel is straight for 300 feet above and 500 feet below the station, and is about 125 feet wide at ordinary stages. The banks are high and rocky and not subject to overflow. The bed is rough and rocky, but permanent. The current is rapid; the lowest observed mean velocity is 1.20 feet per second, at gage height 2.42 feet. The gage is read twice daily by Frank H. Carr.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Contoocook River at West Hopkinton, N. H., in 1903 and 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Square feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
July 9	H. K. Barrows	208	1.79	3.00	372
July 14	N. C. Grover	179	1.90	2.93	340
July 30	H. K. Barrows	178	1.71	2.84	305
September 8	do	142	1.55	2.58	220
October 7	N. C. Grover	127	1.20	2.42	153
1904.					
April 8	N. C. Grover and S. K. Clapp.	556	6.15	5.70	3,420
April 22	S. K. Clapp	443	4.70	4.70	2,080
May 24	do	366	3.67	4.18	1,340
June 7	do	242	2.71	3.36	655
August 4	do	164	1.51	2.62	247
September 27	T. W. Norcross	160	1.43	2.60	229
October 15	do	202	1.47	2.91	298
November 4	do	169	1.40	2.68	237

Mean daily gage height, in feet, of Contoocook River at West Hopkinton, N. H., for 1904.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	5.55	7.80	3.50	3.65	3.00	2.60	3.35	2.90	[a]3.75
2	.....	6.30	6.80	3.45	4.00	2.80	2.70	3.25	2.90	[a]3.70
3	.....	6.70	6.25	3.40	3.90	2.70	2.65	3.05	2.90	[a]3.70
4	.....	6.15	5.30	3.40	3.60	2.80	2.70	3.00	2.90	[a]3.70
5	.....	5.70	4.90	3.40	3.20	2.80	2.70	3.00	2.90	[b]
6	.....	5.60	4.50	3.40	3.15	2.70	2.65	2.90	2.90	.....
7	.....	5.80	4.30	3.60	3.10	2.70	2.65	2.90	2.85	.....
8	.....	6.00	4.20	3.80	3.10	2.70	2.70	2.90	2.80	.....
9	.....	6.35	4.10	3.70	3.00	2.70	2.70	2.80	2.85	.....
10	.....	7.70	4.30	3.55	2.95	2.60	2.70	2.80	2.80	.....
11	.....	8.15	5.00	3.40	2.90	2.80	2.60	2.75	2.80	.....
12	.....	7.15	5.10	3.30	2.85	3.40	2.70	2.90	2.80	.....
13	.....	6.30	4.80	3.15	2.85	3.25	2.70	3.00	2.80	.....
14	.....	5.85	4.40	3.10	2.80	3.10	2.60	3.10	2.80	.....
15	.....	5.40	4.20	3.20	2.80	2.90	3.80	3.10	2.90	.....
16	.....	5.15	4.50	3.10	2.75	2.80	4.80	3.10	3.05	.....
17	.....	5.00	4.50	3.10	2.75	2.75	4.55	3.00	3.10	.....
18	.....	5.00	4.30	3.00	2.80	2.65	3.85	2.80	3.10	.....
19	.....	5.20	5.00	3.00	2.80	2.60	3.50	2.80	3.15	.....
20	.....	5.30	6.20	2.90	2.80	2.70	3.15	2.90	3.00	.....
21	.....	5.10	5.85	2.90	2.85	3.35	3.05	3.00	3.10	.....
22	.....	4.90	5.30	2.90	2.80	3.60	2.90	3.60	3.20	.....
23	.....	4.70	4.80	2.90	2.80	3.30	2.80	3.80	3.20	.....
24	.....	4.50	4.40	2.95	2.75	3.00	2.80	3.55	3.30	.....
25	.....	4.55	4.20	2.95	2.80	2.90	2.80	3.35	3.30	.....
26	.....	4.50	4.20	2.90	2.80	2.80	2.80	3.25	3.20	.....
27	12.70	4.50	4.20	2.90	2.90	2.80	2.80	3.20	3.20	.....
28	10.90	6.00	4.05	2.80	2.90	2.70	2.85	3.15	[a]3.40	.....
29	8.50	8.70	3.80	2.75	2.90	2.70	2.85	3.00	[a]3.70	.....
30	6.85	9.30	3.65	3.00	2.90	2.60	3.10	3.00	[a]3.60	.....
31	6.25	.....	3.55	.....	2.80	2.60	.....	2.90	.....	.....

[a] Anchor ice affects gage heights.
[b] River frozen over. Gage not read during frozen season.

Rating table for Contoocook River at West Hopkinton, N. H., from July 9, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.5	185	3.6	825	4.7	2,060	5.8	3,580
2.6	220	3.7	915	4.8	2,195	5.9	3,720
2.7	255	3.8	1,005	4.9	2,330	6.0	3,860
2.8	295	3.9	1,100	5.0	2,465	6.1	4,005
2.9	335	4.0	1,200	5.1	2,600	6.2	4,150
3.0	380	4.1	1,310	5.2	2,740	6.4	4,440
3.1	435	4.2	1,420	5.3	2,880	6.6	4,730
3.2	500	4.3	1,540	5.4	3,020	6.8	5,020
3.3	570	4.4	1,660	5.5	3,160	7.0	5,310
3.4	650	4.5	1,790	5.6	3,300		
3.5	735	4.6	1,925	5.7	3,440		

The above table is applicable only for open-channel conditions. It is based upon 13 discharge measurements made during 1903 and 1904. It is well defined between gage heights 2.5 feet and 5.70 feet. The table has been extended beyond these limits. Above gage height 6 feet the rating curve is a tangent, the difference being 145 per tenth.

Estimated monthly discharge of Contoocook River at West Hopkinton, N. H., for 1903 and 1904.

[Drainage area, 410 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1903.					
July 9–31	1,150	295	489	1.19	1.02
August	650	210	366	.893	1.03
September	408	161	240	.585	.653
October	1,150	170	488	1.19	1.37
November 1–25	1,081	248	396	.966	.898
1904.					
April	8,645	1,790	3,751	9.15	10.2
May	6,470	780	2,231	5.44	6.27
June	1,005	275	516	1.26	1.41
July	1,200	275	418	1.02	1.18
August	825	220	340	.829	.956
September	2,195	220	467	1.14	1.27
October	1,005	275	442	1.08	1.24
November 1–27	570	295	387	.944	.948

SUNCOOK RIVER AT EAST PEMBROKE, N. H.

This stream enters the Merrimac about 6 miles below Concord and is about 27 miles long, with a total drainage area of about 270 square miles. The drainage basin is hilly and broken; the bed and banks are apt to be rocky. This stream has a large fall, a considerable part of which has been developed.

A gaging station was established at East Pembroke on November 3, 1904, by H. K. Barrows. The drainage area at this point is about 250 square miles. A wooden staff gage is fastened to the abutment of the highway bridge over the canal channel to a mill near this point, which was recently destroyed by fire. This is near the Allenstown station on the Boston and Maine Railroad. At present all of the water, except a slight amount of leakage through the dam, goes through this canal. This is intended as a temporary station, and the gage is read by George P. Cass, of East Pembroke. The records of flow at this point will be published when completed.

Observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

SUDBURY RIVER AT FRAMINGHAM AND LAKE COCHITUATE AT COCHITUATE, MASS.

Sudbury River, a small stream of eastern Massachusetts, receives water from an area west of Framingham. It flows thence in a northerly course through meadows and swamps and joins Assabet River to form Concord River, which in turn continues northerly, entering Merrimac River immediately below the city of Lowell. Storage reservoirs have been constructed by the city of Boston and the Metropolitan Water and Sewerage Board, controlling the greater part of the flow from this basin.

Lake Cochituate drains into Sudbury River a short distance below Framingham. It is controlled as a storage reservoir by the Metropolitan Water Works.

Sudbury River and Lake Cochituate have been studied by the engineers of the city of Boston, the State board of health of Massachusetts, and the Metropolitan Water and Sewerage Board, and records of rainfall in the Sudbury basin have been kept since 1875, and in the Cochituate basin since 1852, but the latter are considered of doubtful accuracy previous to 1872. The records of run-off from 1875 to 1898, inclusive, for Sudbury River, were published in the Twentieth Annual Report, Part IV, and those for Lake Cochituate from 1863 to 1899, inclusive, in Water-Supply and Irrigation Paper No. 35.

The following tables, furnished by Frederic P. Stearns, give the results for 1904; also the averages for thirty years for Sudbury River, and for forty-two years for Lake Cochituate.

Estimated monthly run-off of Sudbury River at Framingham, Mass.

Month.	Run-off.		Rainfall in inches.
	Second-feet per square mile.	Depth in inches.	
1904.			
January	0.738	0.851	4.87
February	1.365	1.472	3.00
March	4.640	5.349	2.72
April	5.096	5.685	8.87
May	2.699	3.112	2.65
June	.648	.723	2.80
July	.096	.111	1.96
August	.262	.303	3.86
September	.614	.685	5.80
October	.295	.348	1.64
November	.447	.499	1.73
December	.417	.481	2.92
The year	1.441	19.619	42.82
1875–1904.			
January	1.882	2.170	4.21
February	2.879	3.023	4.34
March	4.620	5.326	4.59
April	3.273	3.652	3.61
May	1.766	2.036	3.34
June	.807	.901	3.09
July	.299	.345	3.67
August	.450	.519	4.06
September	.368	.411	3.32
October	.327	.903	4.22
November	1.343	1.500	3.96
December	1.675	1.931	3.81
The year	1.673	22.717	46.22

Yield and rainfall in Lake Cochituate watershed.

[Drainage area, 18.87 square miles.]

Month.	Total yield in million gallons.	Yield of 1 square mile.		Total rainfall in inches.	Rainfall collected in inches.	Per cent collected.
		Million gallons per day.	Cubic feet per second.			
1904.						
January	343.9	0.588	0.910	4.75	1.05	22.1
February	412.6	.754	1.167	3.11	1.26	40.5
March	1,553.3	2.655	4.108	2.78	4.73	170.4
April	1,717.7	3.034	4.695	8.68	5.24	60.4
May	768.1	1.313	2.032	2.14	2.34	109.5
June	178.8	.316	.489	2.86	.55	19.1
July	22.4	.038	.059	1.80	.07	3.8
August	150.6	.257	.398	3.32	.49	14.8
September	329.5	.582	.901	6.78	1.00	14.8
October	137.8	.236	.364	1.66	.42	25.3
November	277.3	.490	.758	1.84	.85	46.0
December	263.9	.451	.698	2.39	.80	33.7
The year.	6,155.9	.891	1.379	42.11	18.80	44.6
1863–1904.						
January	27,622.0	1.124	1.739	165.60	2.01	50.9
February	35,927.9	1.606	2.484	169.39	2.61	64.7
March	54,884.1	2.234	3.455	186.91	3.98	89.5
April	41,312.8	1.738	2.688	155.31	3.00	81.1
May	24,495.9	.997	1.543	156.57	1.78	47.7
June	11,124.8	.468	.691	126.51	.81	26.8
July	7,329.6	.298	.462	173.60	.53	12.9
August	10,469.7	.426	.659	185.03	.76	17.3
September	10,031.9	.422	.653	147.27	.73	20.8
October	14,298.3	.582	.376	185.03	1.04	23.6
November	19,485.2	.820	1.268	175.20	1.42	33.9
December	23,651.8	.963	1.489	148.95	1.72	48.4
The year.	280,634.0	.970	1.500	1,975.37	20.38	43.3

Yield, in cubic feet per second per square mile, of Lake Cochituate watershed, 1900–1904.[a]

[Drainage area, 18.87 square miles.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1900	1.060	4.136	4.020	1.454	1.641	0.455	0.293	0.558	0.640	0.689	1.067	1.502	1.445
1901	.840	.629	3.845	4.649	3.704	1.019	.792	1.101	1.012	1.083	1.034	3.675	1.959
1902	2.071	1.934	6.022	2.741	.955	.319	.398	.604	.688	.814	.710	2.052	1.612
1903	2.184	2.734	4.311	3.106	.689	2.132	.553	.408	.130	.886	.534	.815	1.531
1904	.910	1.167	4.108	4.695	2.032	.489	.059	.398	.901	.364	.758	.698	1.379

[a] Corrected for water drawn from Dudley Pond.

NASHUA RIVER (SOUTH BRANCH) AT CLINTON, MASS.

Since July, 1896, the flow of the South Branch of Nashua River has been measured at Clinton by the engineers of the Metropolitan Water and Sewerage Board. The results of these measurements have been furnished by Frederic P. Stearns, chief engineer. A large storage reservoir is now being constructed at Clinton, Mass. Water was stored to an appreciable extent in this reservoir during 1903. Beginning with 1897 the flow has been corrected for loss and gain of storage in ponds and mill reservoirs on the watershed, so that the results show the natural flow of the stream. The following tables give the results for 1904, also the average for the years 1897–1904, inclusive.

Yield and rainfall in Nashua River (South Branch) Watershed.

[Drainage area, 119 square miles.]

Month.	Total yield in million gallons.	Yield of 1 square mile.		Total rainfall in inches.	Rainfall collected in inches.	Per cent collected.
		Million gallons per day.	Cubic feet per second.			
1904.						
January	2,432.6	0.659	1.020	4.02	1.176	29.3
February	3,198.7	.927	1.434	2.66	1.547	58.1
March	11,094.8	3.008	4.653	3.40	5.361	157.7
April	10,654.1	2.984	4.617	7.45	5.149	69.1
May	5,524.5	1.498	2.317	2.99	2.671	89.3
June	2,719.8	.762	1.179	3.44	1.315	38.2
July	1,832.5	.497	.769	3.84	.886	23.1
August	1,309.1	.355	.549	3.68	.633	17.2
September	1,763.7	.494	.764	5.30	.853	16.1
October	1,281.9	.347	.538	1.78	.620	34.8
November	1,222.9	.343	.530	1.62	.591	29.0
December	1,621.5	.440	.680	2.88	.784	27.2
The year.	44,656.1	1.025	1.550	43.06	21.586	50.2
1897–1904.						
January	34,554.1	1.171	1.811	28.94	2.088	57.7
February	41,853.9	1.563	2.418	33.09	2.530	61.2
March	94,026.6	3.186	4.930	40.29	5.683	112.8
April	74,906.4	2.623	4.058	36.00	4.528	100.6
May	39,191.8	1.328	2.054	27.60	2.369	68.7
June	26,547.5	.929	1.438	35.15	1.605	36.5
July	15,625.2	.530	.819	35.48	.944	21.3
August	15,828.9	.536	.830	36.55	.957	20.9
September	10,218.0	.358	.553	28.24	.617	17.5
October	18,124.6	.614	.397	30.04	1.095	29.2
November	24,581.8	.861	.556	30.15	1.486	39.4
December	46,998.0	1.593	2.464	39.01	2.840	58.3
The year.	442,456.8	1.273	1.969	400.54	26.742	53.4

Yield, in cubic feet per second per square mile, of Nashua River (South Branch) watershed, 1897–1904.

[Drainage area, 119 square miles.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1897....	1.232	1.440	4.270	2.525	1.800	1.828	2.231	1.386	0.528	0.377	1.984	3.521	1.938
1898....	2.418	2.530	4.778	3.137	2.151	1.281	.514	2.049	1.045	2.334	3.358	3.189	2.400
1899....	3.236	1.687	4.295	5.224	1.344	.869	.548	.365	.387	.379	.665	.555	1.626
1900....	1.232	6.271	5.759	2.444	2.139	.894	.336	.304	.197	.437	1.354	2.429	1.956
1901....	.808	.551	4.205	7.711	4.222	1.525	.738	.792	.495	1.001	.799	5.002	2.332
1902....	2.579	2.168	6.176	3.341	1.595	.635	.452	.459	.372	1.471	.982	2.859	1.930
1903....	1.957	3.300	5.297	3.463	.880	3.297	.966	.784	.580	1.065	.981	1.476	1.988
1904....	1.020	1.434	4.653	4.617	2.317	1.179	.769	.549	.764	.538	.530	.680	1.550

BLACKSTONE RIVER DRAINAGE BASIN.

Blackstone River rises in Worcester County, near the city of Worcester, flowing in a southeasterly course and emptying into Providence River at Providence, below Pawtucket, where it is generally known as Seekonk River. It has always been important as a water-power stream, and has been very fully developed in this way. There are no large lakes in the basin but numerous small ponds and reservoirs used for storage, and the flow of the river is quite constant. It has numerous tributaries, all of which, though small, are utilized for power purposes.

A gaging station was maintained by the United States Geological Survey at Berkeley, R. I., from May, 1901, through the year 1902, and records obtained at this point may be found in Water-Supply and Irrigation Papers Nos. 65 and 82. This station has been discontinued, owing to backwater influence from dams and generally unsatisfactory conditions. The United States Geological Survey maintains a gaging station on Blackstone River at the present time at Woonsocket, R. I.

BLACKSTONE RIVER AT WOONSOCKET, R. I.

This station was established April 5, 1904, by N. C. Grover. It is located at "River Street Bridge," about midway between the railroad station at Woonsocket, R. I., and that of Blackstone, Mass., being 1½ miles from either of these two points. The drainage area at this point is 360 square miles. It is about 1 mile below the dam at Blackstone and one-half mile above the dam at Woonsocket, and probably the flow is somewhat influenced by this latter.

A standard chain gage is attached to the upstream side of the steel highway bridge; length of chain, 22.57 feet. The gage is referred to bench marks as follows: (1) On the corner of the upstream face of the right abutment; elevation, 18.23 feet above gage datum. (2) A marked point on the bridge near the gage; elevation, 20.26 feet above gage datum. (3) On the upstream face of left abutment; elevation, 18.46 feet above gage datum.

Discharge measurements are made from the 2-span bridge to which the gage is attached. The initial point for soundings is the face of the right abutment on the downstream side. The channel is straight for about 500 feet above and 800 feet below the station. The banks are high, rocky, and clean, and are not subject to overflow. The bed of the stream is of rock, gravel, and sand, and free from vegetation. The velocity is medium, but well sustained during low water. The gage is read twice daily by Gerald Fitzgerald.

Observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Blackstone River at Woonsocket, R. I., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Square feet.	*Ft. per sec.*	*Feet.*	*Second-feet.*
April 5	N. C. Grover	741	1.82	4.04	1,350
April 5	S. K. Clapp	745	1.95	4.15	1,450
May 6	do	767	2.09	4.05	1,610
June 4	do	610	1.16	3.01	710
June 24	do	613	.95	2.87	583
August 3	do	553	.86	2.56	475
August 20	do	557	.79	2.54	439
September 19	H. K. Barrows	576	.88	2.60	509

Mean daily gage height, in feet, of Blackstone River at Woonsocket, R. I., for 1904.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	6.0	3.0	2.8	2.6	2.2	2.3	2.4	2.4
2	.....	5.4	3.0	2.8	2.6	2.2	2.0	2.4	2.3
3	.....	4.8	3.0	2.6	2.5	2.2	2.5	2.4	2.2
4	.....	4.3	3.0	2.7	2.6	2.5	2.4	2.4	[a]1.8
5	4.1	4.0	3.0	2.8	2.6	2.5	2.4	2.3	2.2
6	4.0	4.0	3.0	2.8	2.3	2.2	2.4	2.4	2.2
7	3.6	3.6	3.0	2.8	2.6	2.2	2.4	2.3	2.2
8	3.8	3.6	3.2	2.8	2.4	2.2	2.4	2.2	2.2
9	3.8	3.8	3.2	2.2	2.2	2.3	2.4	2.2	2.2
10	5.4	4.4	3.0	2.4	2.2	2.1	2.4	2.2	2.3
11	6.2	4.4	3.0	2.6	2.4	2.5	2.4	2.4	2.5
12	5.2	4.2	2.9	2.8	2.4	2.4	2.4	[a]1.9	2.4
13	5.0	3.7	3.0	2.8	2.1	2.4	2.6	[a]1.8	2.3
14	4.6	3.6	2.9	2.7	2.6	2.4	2.6	2.4	2.2
15	4.4	3.5	2.8	2.8	2.6	3.2	2.4	2.5	2.2
16	4.2	3.6	2.8	2.1	2.4	4.2	2.4	2.5	2.2
17	4.2	3.4	2.8	2.6	2.5	3.8	2.4	2.5	[b]2.0
18	4.0	3.3	2.7	2.8	2.4	3.0	2.4	2.6	.....
19	3.6	3.4	2.8	2.7	2.4	2.8	2.4	2.6	.....
20	3.6	3.6	2.8	2.6	2.2	2.8	2.4	2.6	.....
21	3.8	3.4	2.8	2.6	2.8	2.6	2.6	2.5	.....

[a] Gage height not true indication of flow as water was drawn down at dam one-half mile below.
[b] River frozen over.

Mean daily gage height, in feet, of Blackstone River at Woonsocket, R. I., for 1904—Con.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
22	3.6	3.4	2.6	2.5	2.7	2.5	2.6	2.6	.....
23	3.3	3.4	2.7	2.4	2.6	2.6	2.4	2.4	.....
24	3.2	3.2	2.8	2.7	2.4	2.6	2.4	2.6	.....
25	3.2	3.2	2.7	2.5	2.5	2.4	2.4	2.4	.....
26	2.9	3.2	2.7	2.6	2.8	2.5	2.5	2.5	.....
27	3.2	3.2	2.8	2.6	2.4	2.5	2.6	2.5	.....
28	6.0	3.0	2.5	2.5	2.6	2.5	2.4	2.6	.....
29	8.7	2.9	2.6	2.6	2.2	2.6	2.1	2.6	.....
30	7.6	2.9	2.8	2.2	2.2	2.3	[a]1.8	2.5	.....
31	.....	3.0	.....	2.6	2.2	.....	2.4	.....	.....

[a] Gage height not true indication of flow as water was drawn down at dam one-half mile below.

THAMES RIVER DRAINAGE BASIN.

This stream drains the eastern part of Connecticut and small portions of Rhode Island and Massachusetts. The country thus included is hilly and contains many natural lakes and ponds which have been improved for reservoir purposes. This is a great manufacturing section, being especially noted for its cotton and woolen industries, and there are many important water-power privileges, both developed and undeveloped.

The Thames is formed at Norwich, Conn., by the union of the Shetucket and Yantic rivers, and at a distance of about 4½ miles from New London enters Long Island Sound. It is a tidal stream below Norwich. A few miles above Norwich Quinnebaug River enters the Shetucket from the east. This stream is the most important tributary of the Shetucket as regards size, storage facilities, etc. It rises in the southern part of Massachusetts in the town of Brimfield, and has a total length of about 60 miles. At Willimantic the Shetucket divides into the Willimantic and Nachaug rivers, which are, especially the former, important water-power streams.

Drainage areas of the Thames and its principal tributaries are given in the following table:

Drainage areas of Thames River and its principal tributaries.

River.	Locality.	Area.
		Square miles.
Thames	Norwich	1,300
Do	New London	1,400
Willimantic	Mouth	223
Nachaug	....do	169
Quinnebaug	....do	688
Shetucket	....do	1,200
Yantic	....do	98

The United States Geological Survey maintains a gaging station on Shetucket River a short distance below Willimantic, Conn.

SHETUCKET RIVER NEAR WILLIMANTIC, CONN.

This station was established April 4, 1904, by N. C. Grover. It is located at the highway bridge (locally known as Bingham Bridge), about 1 mile below Willimantic and 1 mile below the junction of Willimantic and Nachaug rivers. The drainage area at this point is 396 square miles. A standard chain gage is attached to the downstream side of the bridge near the center of the left span; length of chain, 22.49 feet. The gage is referred to bench marks as follows: (1) Marked point on bridge near the gage scale; elevation, 21.46 feet. (2) Top of left abutment on the downstream corner; elevation, 21.76 feet. (3) Top of face of right abutment on the downstream corner; elevation, 21.19 feet. (4) Top of downstream point of the pier; elevation, 19.77 feet. All elevations are referred to gage datum.

Discharge measurements are made from the 2-span steel bridge, total length 200 feet, to which the gage is attached. The initial point for soundings is the extreme outer edge of the end column of the downstream truss at the left bank. The channel is straight for about 800 feet above and below the station, and there are two channels at all stages. The banks are high, rocky, and clean, and not subject to overflow. The bed of the stream is of rock and permanent. Current is swift at all stages. The gage is read twice daily by Mrs. John Houle.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Shetucket River near Willimantic, Conn., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Square feet.	*Ft. per sec.*	*Feet.*	*Second-feet.*
April 4	N. C. Grover	689	2.32	4.78	1,600
May 5	S. K. Clapp	608	2.13	4.15	1,290
June 3	do	420	1.38	3.00	580
June 23	do	380	.84	2.54	320
August 2	do	392	1.13	2.79	443
August 19	do	401	.87	2.62	350
September 19	H. K. Barrows	468	1.16	3.08	544
October 3	T. W. Norcross	427	1.10	2.82	470
October 18	do	410	.97	2.70	400
November 28	do	435	1.13	2.99	493

Mean daily gage height, in feet, of Shetucket River at Willimantic, Conn., for 1904.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	5.6	3.1	2.4	1.9	2.2	2.3	2.5	2.5
2	.....	4.8	3.1	2.2	2.8	2.1	2.4	2.4	2.5
3	.....	4.6	3.0	2.2	2.7	2.2	2.8	2.6	2.0
4	5.0	4.3	3.0	2.2	2.5	1.8	2.2	2.5	2.6
5	4.5	4.1	2.8	2.4	2.8	1.6	2.2	2.4	2.4
6	4.2	3.7	2.7	2.5	2.6	2.2	2.3	2.0	2.2
7	4.3	3.5	2.7	2.4	2.4	2.2	2.2	2.6	2.4
8	4.6	3.6	2.8	2.4	2.9	2.4	2.7	2.4	2.4
9	4.6	4.2	3.0	2.3	2.4	1.8	2.4	2.5	2.2
10	7.6	4.4	3.0	2.3	2.6	2.0	2.9	2.6	2.4
11	6.8	4.5	2.8	2.3	3.6	2.2	2.4	2.3	1.9
12	5.8	4.1	2.7	2.3	3.4	2.1	2.4	2.2	3.2
13	5.6	3.7	2.4	2.3	2.8	2.2	2.8	2.4	2.7
14	5.0	3.4	2.6	2.3	2.4	1.9	3.1	3.9	2.6
15	4.6	3.5	2.6	2.3	2.5	5.2	2.9	3.8	2.3
16	4.6	3.9	2.6	2.4	2.5	6.2	2.6	3.4	3.8
17	4.9	4.2	2.5	1.7	2.1	4.0	3.0	3.0	3.8
18	4.5	3.9	2.5	2.1	2.4	3.2	2.6	3.0	[a]2.9
19	4.2	3.6	1.9	2.1	2.4	3.0	2.8	2.6	[b]2.4
20	4.0	3.8	2.2	2.0	2.3	2.9	2.4	2.4	[c]1.6
21	4.0	3.5	2.2	2.0	3.7	2.6	2.7	2.8	[d]1.8
22	3.8	3.3	2.2	2.0	3.8	2.6	3.8	2.8	[b]2.5
23	3.6	3.2	2.2	2.0	3.2	2.0	3.4	2.8	[c]2.6
24	3.5	3.1	2.2	1.7	3.1	2.2	3.0	2.6	[d]2.4
25	3.6	3.0	2.2	2.2	2.4	2.5	3.0	2.6	[d]2.4
26	3.6	3.0	1.7	2.5	2.3	2.2	2.8	2.3	[b]2.9
27	3.8	3.0	2.2	2.6	1.9	2.6	2.8	2.4	[b]3.6
28	6.4	3.0	2.2	2.6	1.9	2.6	3.0	2.8	[f]5.8
29	7.3	2.8	2.2	2.5	2.2	2.6	2.7	2.4	7.0
30	6.5	2.7	2.2	1.9	2.2	2.4	2.5	2.5	6.6
31	.....	3.0	.....	1.8	2.3	.....	2.6	.....	4.8

[a] River frozen on December 18.
[b] Ice 0.4 foot thick.
[c] Ice 0.15 foot thick.
[d] Ice 0.25 foot thick.
[e] Ice 0.35 foot thick.
[f] No ice December 28–31.

NOTE.—During frozen season gage heights are to surface of water in hole cut in ice.

CONNECTICUT RIVER DRAINAGE BASIN.

Connecticut River has its source in Connecticut Lake, in northern New Hampshire. Its extreme headwaters, however, lie in the Province of Quebec and in the mountains on the northern boundary of New Hampshire; thence the river flows in a southerly direction between New Hampshire and Vermont and through Massachusetts and Connecticut into Long Island Sound. The total drainage area is 11,085 square miles, of which 155 square miles lie in the Province of Quebec. Its total length from Connecticut Lake to Long Island Sound is 345 miles. On its banks are many cities and towns of importance. It is in general closely followed by one or more railroad lines. Water power is used at several points, notably at Windsor locks in Connecticut, Holyoke and Turners falls in Massachusetts, and Bellows Falls and

Wilder in Vermont. The valley of Connecticut River proper is very generally in farm lands. Many of its tributary basins, however, especially in the northern portions, are heavily wooded.

Estimates of the flow of this river at Hartford, Conn., from 1871 to 1885, inclusive, have been published in the Fourteenth Annual Report of the United States Geological Survey, Part II, pages 140–146. Estimates of flow at Holyoke, Mass., from 1880 to 1895, inclusive, have been published in Bulletin No. 140, pages 37–41, and for 1896 and 1897 in the Nineteenth Annual Report, Part IV, page 116. The drainage areas of the river and of several of its tributaries are given in the following table:

Drainage area of Connecticut River and tributaries.

River.	Locality.	Area.
		Square miles.
Connecticut	In Canada	155
Do	Orford, N. H.	3,305
Do	Sunderland, Mass	7,700
Do	Hartford, Conn	10,235
Do	Mouth	11,085
Israel	Above South Branch	8.7
Do	Below South Branch	21.2
Ammonoosuc	Bretton Woods, N. H	34
Zealand	Mouth	14
Little	do	12
White	Sharon, Vt	680
Ashuelot	Winchester, N. H	385
Deerfield	Mouth	667
Do	Deerfield, Mass	550
Chicopee	Mouth	730
Ware	do	223
Do	Gilbertville, Mass	160
Do	Ware, Mass	162
Quaboag	Mouth	213
Do	West Warren, Mass	144
Swift	Mouth	218
Do	West Ware, Mass	188
Westfield	Mouth	518
Do	Russell, Mass	331

The United States Geological Survey maintains gaging stations in this basin on Connecticut River near Orford, N. H.; on Connecticut River at Sunderland, Mass.; on Israel River near Jefferson Highlands, N. H.; on Ammonoosuc River at Bretton Woods, N. H.; on Zealand River near Twin Mountain, N. H.; on Little River near Twin Mountain, N. H.; on White River at Sharon, Vt.; on Ashuelot River at Winchester, N. H.; on Deerfield River at Deerfield, Mass.; on Ware River near Ware, Mass.; on Quabog River near West Warren, Mass.; on Westfield River at Russell, Mass.

In addition, data regarding flow are obtained at the following places, through the assistance of private parties or corporations: Connecticut River at Hartford, Conn.; Ware River at Gilbertville, Mass.; and Swift River at West Ware, Mass.

CONNECTICUT RIVER NEAR ORFORD, N. H.

This station was established August 6, 1900, by E. G. Paul. It is located at the wooden highway bridge between Orford, N. H., and Fairlee, Vt., and is about 75 miles from the source of the stream. The drainage area at this point is 3,305 square miles. A standard chain gage is attached to the inside timbers of the upper side of the bridge, 125 feet from the left abutment; length of chain, 42.95 feet. It is referred to bench marks as follows: (1) Top of downstream corner of right abutment at face; elevation, 30.34 feet. (2) Top of downstream corner of left abutment at face; elevation, 31.08 feet. (3) Nail in root of elm tree on Orford side, 28.4 feet from southwest corner of bridge and 11.6 feet from produced line of downstream side of bridge; elevation, 40.11 feet. Elevations are above gage datum. The channel is straight for at least 1,000 feet above and 1,000 feet below the station, is about 275 feet wide at ordinary stages of the river, and is broken by one pier. The bed is of gravel and permanent, while the current is strong. The gage is read once daily by Frank H. Gardner, of Orford, N. H.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Connecticut River near Orford, N. H., 1900–1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1900.		*Feet.*	*Square feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
August 7	E. G. Paul	235	1,110	1.38	3.60	1,530
1901.						
April 15	C. A. Holden	322	5,367	3.16	17.40	[a] 17,000
June 22	do	275	2,077	2.04	6.80	4,240
October 5	do	231	1,069	1.36	3.47	1,460
November 2	do	235	1,143	1.39	3.67	1,590
1902.						
April 10	C. A. Holden	296	3,510	3.06	11.63	10,700
November 22	do	278	2,140	2.09	6.80	4,470
1903.						
January 24	C. A. Holden	276	1,760	1.69	[b] 7.20	2,970
January 29	do	273	1,610	1.63	[c] 6.60	2,620
January 29	do	273	1,620	1.66	[d] 6.90	2,690
January 30	do	276	1,760	1.69	[b] 7.40	2,980
February 7	do	278	1,810	1.65	[e] 7.45	2,990
February 7	do	278	1,810	1.67	[e] 7.45	3,030
March 14	do	325	6,510	3.79	20.70	[a] 24,700
April 23	do	294	2,530	2.46	8.25	6,220
June 2	E. C. Murphy	280	1,040	1.13	3.26	1,170
July 16	N. C. Grover	264	1,180	1.29	3.53	1,520
August 29	C. A. Holden	252	1,450	1.48	4.55	2,150
September 19	do	225	826	.93	2.30	768
September 26	do	225	778	.87	2.13	673
1904.						
February 3	C. A. Holden	240	851	1.04	[f] 4.15	884
February 3	do	241	847	1.03	[g] 4.12	876
February 4	do	239	804	.98	[h] 4.08	785
February 4	do	236	804	.99	[i] 4.20	792
February 5	do	235	813	.97	[j] 4.03	790
February 5	do	235	805	.99	[j] 4.03	799
April 30	do	324	5,540	3.78	18.03	20,900
July 6	S. K. Clapp	275	1,480	1.59	4.74	2,350

[a] Discharge estimated.
[b] Gage height to bottom of ice 6.0 feet.
[c] Gage height to bottom of ice 5.4 feet.
[d] Gage height to bottom of ice 5.5 feet.
[e] Gage height to bottom of ice 6.05 feet.
[f] Gage height to bottom of ice 2.4 feet; ice 1.9 feet thick.
[g] Gage height to bottom of ice 2.37 feet; ice 1.95 feet thick.
[h] Gage height to bottom of ice 2.22 feet; ice 2.05 feet thick.
[i] Gage height to bottom of ice 2.19 feet; ice 2.05 feet thick.
[j] Gage height to bottom of ice 2.23 feet; ice 2.0 feet thick.

NOTE.—Gagings January 24 to February 7, 1903, and February 3 to 5, 1904, made through ice. Gage heights given in table are to surface of water in hole in ice.

Mean daily gage height, in feet, of Connecticut River near Orford, N. H., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.3	4.2	4.8	13.9	18.0	7.2	4.1	3.7	3.5	10.4	6.3	4.8
2	4.2	4.2	4.8	13.4	18.2	6.8	4.0	3.8	3.3	11.7	6.1	.....
3	4.2	4.2	4.8	13.2	17.4	6.6	4.0	3.8	3.4	11.5	6.1	4.4
4	4.2	4.1	4.8	11.9	17.2	6.1	4.2	3.6	3.4	11.1	5.9	a4.6
5	4.3	4.1	4.9	10.4	16.6	6.0	4.8	3.5	4.7	10.6	5.8	4.4
6	4.3	4.1	5.2	9.9	15.1	6.0	4.7	3.4	6.4	9.3	5.8	.....
7	4.3	b4.0	5.2	10.8	14.5	6.3	4.3	3.1	6.3	7.6	5.6	.....
8	4.0	4.0	5.3	11.4	13.2	7.4	3.9	2.9	5.5	7.4	5.5	.....
9	4.0	4.1	8.0	13.6	12.0	8.5	3.7	2.6	5.2	7.0	5.4	.....
10	c4.0	4.1	8.3	16.2	12.0	8.1	3.5	2.8	4.8	6.7	5.0	.....
11	3.9	4.1	7.5	17.6	12.2	7.1	3.6	3.4	4.0	6.7	4.8	d4.0
12	3.8	4.1	6.9	17.2	13.9	6.4	2.8	3.4	4.0	6.5	4.6	.....
13	3.8	4.1	6.4	15.8	13.1	5.8	2.9	3.6	3.5	7.0	4.4	.....
14	3.9	e4.1	6.1	14.0	11.2	5.4	3.4	3.8	3.5	6.7	4.9	.....
15	4.0	4.1	6.0	11.6	10.3	5.1	3.9	3.9	4.0	6.6	4.8	.....
16	4.0	4.2	5.8	10.1	14.0	4.7	4.0	3.8	7.5	6.6	f4.8	.....
17	g4.0	4.2	5.6	9.4	16.2	4.6	3.9	4.0	8.0	6.4	h4.6	.....
18	4.0	4.2	5.7	9.6	16.5	4.6	3.9	3.7	7.4	6.2	4.6	i3.8
19	3.9	4.2	5.5	9.4	18.5	4.5	3.1	3.6	6.9	5.9	4.4	.....
20	3.9	4.2	5.4	8.8	18.2	4.5	3.0	3.8	6.5	5.8	4.3	.....
21	3.9	j4.2	5.4	8.8	17.9	4.4	2.8	4.8	6.4	5.8	5.0	.....
22	4.0	4.2	5.6	9.0	15.1	3.7	2.7	6.4	7.6	7.6	5.0	.....
23	4.0	4.3	5.9	9.3	13.0	3.9	2.7	7.2	8.2	8.8	5.2	.....
24	k4.0	4.4	8.4	10.5	11.4	4.0	2.4	6.8	7.1	8.6	5.4	.....
25	4.0	4.4	8.4	11.8	10.3	4.1	2.5	6.6	6.9	8.0	5.5	l3.9
26	4.1	4.6	f13.5	14.8	10.0	4.0	2.6	6.0	8.0	7.9	5.4	.....
27	4.1	4.7	f18.2	15.6	9.5	4.1	2.6	5.2	9.4	7.7	5.0	.....
28	4.1	m4.9	f19.1	16.0	9.1	3.5	3.0	4.8	8.7	7.4	4.9	.....
29	4.2	4.8	n17.6	17.5	8.9	4.3	3.4	4.4	7.7	7.4	4.8	.....
30	4.2	.....	16.0	17.8	8.8	4.1	3.5	3.8	8.4	7.0	4.8	.....
31	b4.2	.....	14.6	.....	8.5	.....	3.6	3.3	.....	6.9	.....	.....

a Ice 0.35 foot thick; reading to surface of water, 4.6.
b Ice 1.85 feet thick; reading to surface of water, 4.0.
c Ice 1.6 feet thick; reading to surface of water, 4.2.
d Ice 0.7 foot thick.
e Ice 1.9 feet thick.
f See rating table note.
g Ice 1.7 feet thick; reading to surface of water, 3.8.
h River frozen over.
i Ice 0.75 foot thick.
j Ice 2.2 feet thick.
k Ice 1.9 feet thick; reading to surface of water, 3.8.
l Ice 1.1 feet thick; reading to surface of water 4.0
m Ice 2.1 feet thick.
n Ice went out March 29.

NOTE.—Gage heights during frozen season to surface of ice except as noted.

Rating table for Connecticut River near Orford, N. H. from March 29[a] to November 16, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.0	640	3.8	1,600	7.2	4,780	10.8	9,400
2.1	680	3.9	1,670	7.4	5,000	11.0	9,700
2.2	725	4.0	1,740	7.6	5,220	11.5	10,450
2.3	770	4.2	1,880	7.8	5,440	12.0	11,200
2.4	815	4.4	2,030	8.0	5,660	12.5	11,980
2.5	860	4.6	2,190	8.2	5,900	13.0	12,770
2.6	905	4.8	2,350	8.4	6,140	13.5	13,560
2.7	950	[illegible]	2,520	8.6	6,380	14.0	14,340
2.8	1,000	5.2	2,700	8.8	6,640	14.5	15,120
2.9	1,050	5.4	2,880	9.0	6,900	15.0	15,910
3.0	1,100	5.6	3,070	9.2	7,160	15.5	16,700
3.1	1,160	5.8	3,270	9.4	7,420	16.0	17,480
3.2	1,220	6.0	3,470	9.6	7,690	16.5	18,260
3.3	1,280	6.2	3,680	9.8	7,970	17.0	19,050
3.4	1,340	6.4	3,900	10.0	8,250	17.5	19,840
3.5	1,400	6.6	4,120	10.2	8,530	18.0	20,620
3.6	1,460	6.8	4,340	10.4	8,810	19.0	22,190
3.7	1,530	7.0	4,560	10.6	9,100		

[a] Take 75 per cent of discharge in table, March 26, 27, and 28, on account of high water due probably to ice gorging; 90 per cent of discharge in table, November 17 to 30 on account of river being covered with thin ice.

The above table is applicable only for open-channel conditions. It is based upon 15 discharge measurements made during 1900 to 1904, inclusive. It is well defined between gage heights 2 feet and 12 feet. The table has been extended beyond these limits. Above gage height 12 feet the rating curve is a tangent, the difference being 157 per tenth. Two estimated and one measured discharge are used as the basis for extending the curve above gage height 12 feet.

Rating table for Connecticut River near Orford, N. H., from January 1 to March 25, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
4.0	800	4.65	1,190	5.6	1,820	6.9	2,730
4.05	830	4.7	1,220	5.7	1,890	7.0	2,800
4.1	860	4.75	1,250	5.8	1,960	7.1	2,870
4.15	890	4.8	1,280	5.9	2,030	7.2	2,940
4.2	920	4.85	1,310	6.0	2,100	7.3	3,010
4.25	950	4.9	1,340	6.1	2,170	7.4	3,080
4.3	980	4.95	1,370	6.2	2,240	7.5	3,150
4.35	1,010	5.0	1,400	6.3	2,310	7.6	3,220
4.4	1,040	5.1	1,470	6.4	2,380	7.7	3,290
4.45	1,070	5.2	1,540	6.5	2,450	7.8	3,360
4.5	1,100	5.3	1,610	6.6	[illegible]	7.9	3,430
4.55	1,130	5.4	1,680	6.7	2,590	8.0	3,500
4.6	1,160	5.5	1,750	6.8	2,660		

The above table is applicable only for ice conditions. It is based upon 12 discharge measurements made during 1903 and 1904 through holes cut in the ice. The thickness of ice varied from 1.2 feet to 2.05 feet. It is well defined between gage heights 4 feet and 8 feet.

NOTE.—Gage heights are to water surface.

Estimated monthly discharge of Connecticut River near Orford, N. H., for 1904.

[Drainage area, 3,305 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January [a]	980	620	765	0.231	0.266
February [a]	1,220	680	827	.250	.270
March [a]	19,990	1,160	4,688	1.52	1.75
April	20,310	6,640	12,320	3.73	4.16
May	21,400	6,260	13,760	4.16	4.80
June	6,260	1,400	3,009	.910	1.02
July	2,350	815	1,416	.428	.493
August	4,780	905	1,978	.598	.689
September	7,420	1,280	3,693	1.12	1.25
October	10,750	3,270	5,542	1.68	1.94
November [b]	3,790	1,760	2,568	.777	.867
December [c]	.....	.....	1,375	.416	.480
The year	21,400	620	4,328	1.32	16.41

[a] January 17 to March 25, inclusive, gage heights reduced 0.2 foot to bring them to surface of water instead of to surface of ice. This was necessary as ice table was based on gage heights to water surface. Miscellaneous readings to ice and water showed difference of 0.2 foot.

[b] November 17 to 30 river covered with thin ice. Discharge obtained by taking 90 per cent of open-channel flow.

[c] Mean discharge for December based upon discharge for seven days scattered through the month. Owing to thinness of ice the table for ice conditions was not considered applicable. The discharge was obtained by taking 88 per cent of the open-channel discharge with gage height to bottom of ice.

CONNECTICUT RIVER AT SUNDERLAND, MASS.

This station was established March 31, 1904, by N. C. Grover. It is located at a 5-span steel highway bridge, total length being about 830 feet, at Sunderland, Mass. The nearest railway station is at South Deerfield, Mass. The gaging station is about 18 miles above the dam at Holyoke and about 5 miles below that of Turners Falls. The drainage area at this point is about 7,700 miles. A standard chain gage is attached to the downstream side of the bridge near the left bank; length of chain, 42.79 feet. It is referred to bench marks as follows: (1) On the bottom chord of the bridge near the zero of the gage scale; elevation, 37.82 feet. (2) Corner of left bridge seat at the top of the downstream face; elevation, 37.06 feet. (3) Northwest corner of the coping of the downstream end of the pipe culvert, 250 feet east from the left end of bridge; elevation, 32.91 feet. All elevations are referred to gage datum.

Discharge measurements are made from the downstream side of the bridge to which the gage is attached. The initial point for soundings is the face of the left abutment at the top on the downstream side of the bridge. The channel is straight for 1,000 feet above and below the station. Both banks are high, rocky, and wooded and not subject to overflow. The bed of the stream is of gravel, clean, and permanent. There are 5 channels at all stages. The current is swift at high stages and medium at low stages. The gage is read twice daily by John Lawer.

Observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Connecticut River at Sunderland, Mass., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Square feet.	*Ft. per sec.*	*Feet.*	*Second-feet.*
April 12	S. K. Clapp	13,550	4.05	17.65	55,000
April 26	do	9,200	3.75	12.15	34,500
May 17	do	7,760	3.32	10.17	25,800
June 2	do	4,110	2.46	5.45	10,100
June 21	do	2,740	1.93	3.45	5,300
July 29	do	2,070	1.77	2.55	3,660
August 18	do	2,000	1.70	2.60	3,390
October 28	T. W. Norcross	5,000	2.60	6.48	13,000
December 1	do	3,090	1.52	4.63	4,710

Mean daily gage height, in feet, of Connecticut River at Sunderland, Mass., for 1904.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	12.50	19.60	6.35	3.90	3.35	3.10	8.30	5.65	4.60
2	.....	14.50	17.85	5.50	4.55	2.90	2.90	8.10	5.30	4.60
3	.....	14.75	16.25	5.50	4.55	2.75	2.65	8.30	5.15	5.15
4	.....	13.05	15.15	5.35	4.10	3.05	2.40	8.20	5.00	5.50
5	.....	11.70	14.15	5.10	3.75	3.10	2.35	7.60	4.90	4.90
6	.....	11.85	13.05	4.90	3.70	2.95	2.85	6.95	4.75	4.70
7	.....	12.50	12.15	5.50	3.60	2.90	2.85	6.25	4.50	4.80
8	.....	13.70	11.30	6.10	3.60	2.80	3.80	5.70	4.65	4.70
9	.....	15.80	10.50	7.50	3.50	2.25	3.85	5.30	4.40	4.70
10	.....	18.30	10.25	8.00	3.40	2.70	3.60	5.10	4.30	4.50
11	.....	18.55	10.30	6.85	3.15	3.05	3.40	5.25	4.10	[a] 4.10
12	.....	17.55	10.90	5.80	3.05	2.90	3.15	5.50	4.00	.....
13	.....	16.15	11.00	5.15	2.70	2.35	3.00	5.70	3.80	.....
14	.....	14.65	10.35	5.00	2.85	2.30	2.90	5.60	3.85	.....
15	.....	12.90	9.30	4.60	2.70	2.20	6.70	5.60	4.10	.....
16	.....	11.45	9.40	4.30	2.70	1.75	8.70	5.50	4.10	.....
17	.....	10.40	10.10	4.10	2.70	2.55	7.25	5.10	4.10	[b] 3.80
18	.....	9.95	10.90	3.90	2.95	2.60	6.80	5.10	3.75	.....
19	.....	10.20	12.10	3.40	2.85	2.70	6.40	4.85	3.65	.....
20	.....	10.10	14.65	3.10	2.90	3.05	5.65	4.70	3.80	.....
21	.....	9.55	15.10	3.20	2.80	5.15	4.90	4.80	3.85	.....
22	.....	9.25	14.00	3.30	2.55	5.00	4.65	10.20	4.20	.....
23	.....	9.30	12.40	3.10	2.45	5.10	5.10	9.40	4.75	.....
24	.....	9.55	10.70	3.05	1.90	5.00	5.50	8.35	4.70	[c] 3.35
25	.....	10.40	9.40	3.00	2.45	5.10	5.20	7.50	4.60	.....
26	.....	12.10	8.80	2.95	2.55	4.70	5.05	6.80	4.40	.....
27	.....	13.25	8.60	3.00	2.40	4.50	6.10	6.30	4.40	.....
28	.....	16.05	8.10	2.90	2.50	4.10	6.40	6.50	4.35	.....
29	.....	21.25	7.40	3.05	2.60	3.55	6.40	6.40	4.50	.....
30	.....	21.40	7.00	3.20	2.70	3.30	6.90	6.05	4.70	.....
31	13.40	.....	6.85	.....	3.00	3.20	.....	5.80	.....	[d] 5.40

[a] River frozen during night.
[b] Gage height to surface of ice=3.8; ice 0.65 foot thick.
[c] Gage height to surface of ice=3.4; ice 0.90 foot thick.
[d] Gage height is to surface of ice.

CONNECTICUT RIVER AT HARTFORD, CONN.

Daily readings of the height of water at Hartford have been recorded since February 8, 1896, by Edwin Dwight Graves, chief engineer Connecticut River bridge and highway district, and through his courtesy have been furnished to the United States Geological Survey.

These heights are read on what is known as the "Tollhouse gage," the zero of which is set at the low-water mark of 1801.[a] The highest water ever known in the river was in May, 1854—29 feet 10 inches; the lowest, in 1858—1½ inches below zero.

[a] See report Theodore G. Ellis, 1867 (Ex. Doc. H. R. No. 153, 40th Cong., 2d sess.).

This datum was used in the various surveys of the river below Hartford in 1866–67 (see previous reference); also the survey above Hartford in 1871–1878;[a] also survey of 1897.[b] It is now being used in a further survey of the river above Hartford by an engineer commission appointed by the Secretary of War to study the problem of river improvements above Hartford.

During the low-water periods the tidal wave comes up the river to Hartford. The visible effect of this wave is dependent upon the height of the water and the direction and course of the wind.

From figures given in the Report of the Chief of Engineers for 1878, pages 348–391, and from other data, computations of the discharge of Connecticut River at Hartford from 1871 to 1886, inclusive, were prepared and published in the Fourteenth Annual Report of the United States Geological Survey, Part II, pages 140–146.

Mean daily gage height, in feet, of Connecticut River at Hartford, Conn., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.4	3.6	5.2	12.7	19.2	5.4	2.5	1.5	1.9	5.1	4.2	2.5
2	4.3	3.8	5.0	14.1	18.2	5.0	3.8	2.2	2.0	5.7	4.1	2.5
3	3.9	3.5	4.9	15.2	16.7	4.5	3.8	2.5	2.0	5.6	4.0	2.9
4	3.5	3.4	5.7	14.6	15.0	4.2	3.3	2.4	2.0	6.0	4.0	2.6
5	3.9	3.2	6.0	12.7	13.6	3.9	3.0	2.5	1.6	5.7	4.3	2.0
6	3.8	3.4	6.1	11.5	12.3	4.1	2.9	2.6	2.2	5.4	4.1	3.2
7	3.8	3.2	6.5	11.4	11.1	4.5	3.0	2.4	2.7	4.7	3.2	3.1
8	3.8	3.3	11.2	12.0	10.1	5.7	3.0	2.5	2.6	4.3	2.9	3.0
9	4.3	4.0	14.5	13.0	9.5	5.9	2.9	2.4	2.5	3.6	3.0	3.0
10	3.4	3.8	14.8	15.8	9.3	8.2	2.8	2.0	2.5	3.2	3.0	2.9
11	3.5	4.1	13.7	17.4	9.0	7.1	2.6	2.1	1.6	3.5	2.9	2.4
12	4.2	4.3	11.6	17.4	8.8	5.8	2.7	2.1	1.8	3.4	2.5	1.6
13	4.0	4.3	11.0	16.6	9.0	4.9	2.5	2.3	2.1	4.0	2.2	3.4
14	4.1	3.8	9.7	15.3	8.9	4.2	2.0	1.5	2.2	3.9	2.8	3.2
15	3.6	4.0	8.8	13.6	8.3	3.9	2.0	1.2	3.8	3.8	3.2	2.8
16	3.5	4.0	8.0	11.9	7.9	3.7	2.0	2.0	8.9	3.9	3.2	3.2
17	3.1	3.3	7.3	10.5	8.2	3.4	1.5	2.2	8.2	3.8	2.9	3.2
18	2.6	3.2	7.0	9.6	8.6	3.0	1.4	2.0	6.0	3.7	3.5	2.7
19	3.4	3.5	6.9	9.3	9.3	2.4	2.4	1.9	5.1	3.9	3.4	2.4
20	3.4	3.4	6.9	9.3	10.9	2.7	2.4	3.0	4.9	3.7	2.6	3.0
21	3.3	2.7	7.5	9.0	12.6	3.2	2.5	2.3	3.9	4.4	2.7	2.7
22	3.5	3.8	7.1	8.4	12.6	3.2	2.7	3.6	3.0	6.8	3.0	2.3
23	3.8	5.6	6.8	8.0	11.7	2.9	3.1	3.5	3.0	8.4	2.8	2.3
24	3.8	6.0	7.7	7.8	10.3	2.6	2.3	3.2	3.1	7.4	3.5	2.5
25	3.8	6.0	9.7	8.2	8.6	2.5	1.5	3.0	3.4	6.4	3.2	2.0
26	4.4	5.5	11.6	9.0	7.6	2.0	2.0	3.0	3.1	5.6	2.6	1.5
27	4.3	5.5	17.6	10.3	7.3	1.2	1.8	2.5	3.6	4.8	2.2	2.8
28	3.8	4.9	20.0	12.6	7.2	2.1	1.6	2.2	4.0	4.4	2.0	4.0
29	4.0	5.0	18.4	16.3	6.6	2.4	1.7	2.0	4.3	4.6	3.3	4.4
30	4.5	.....	16.0	19.0	5.9	2.2	.9	2.0	4.4	4.3	2.8	4.4
31	3.5	.....	14.1	.....	5.7	.....	1.1	2.3	.....	4.1	.....	4.7

[a] Engineers' Report, 1878, pp. 348–391. [b] Engineers' Report, 1898, pp. 976–988.

ISRAEL RIVER (ABOVE SOUTH BRANCH) NEAR JEFFERSON HIGHLANDS, N. H.

This station was established September 2, 1903, by N. C. Grover. It is located at a small wooden highway bridge in the town of Randolph, about halfway between the railway stations of Jefferson Highlands and Bowman, and 2½ miles from either place. The drainage basin at this point has an area of 8.7 square miles. The headwaters of the river lie on the slopes of Mount Adams and Mount Jefferson, at elevations approximating 5,000 feet. The length of the river from its source to the gaging station is about 5 miles. The elevation at the gaging station is about 1,400 feet. All slopes are steep; many are precipitous. There is no pondage or artificial storage of water. The underlying rock is granite, exposed in the mountain tops. The basin is generally in heavy virgin forest.

A standard chain gage is attached to the upstream truss of the bridge; length of chain, 15.43 feet. It is referred to bench marks as follows: (1) Marked point on east end of cross timber of bridge; elevation, 8.58 feet. (2) Top of bowlder, 150 feet east of bridge, 30 feet south of river; elevation, 11.99 feet. Elevations are above datum of gage. The channel is straight for 100 feet above and 50 feet below the station, and is about 20 feet wide. The banks are subject to overflow in extreme freshet. Velocities at low water average about 0.50 of a foot per second. Low-water measurements are made by wading about 20 feet above the bridge. The bed is gravelly and permanent. The gage is read once daily by E. A. Crawford, of Jefferson Highlands.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements on Israel River (above South Branch) near Jefferson Highlands, N. H., in 1903 and 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Square feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
September 2	H. K. Barrows	14.1	0.67	1.20	9.4
September 18	do	14.1	.57	1.17	8.1
October 9	N. C. Grover	12.6	.46	1.15	5.8
1904.					
April 16	N. C. Grover	23	.94	1.44	22
April 18	do	24	.92	1.48	22
May 1	S. K. Clapp	46	2.18	2.33	100
May 11	do	48	2.44	2.35	117
May 25	do	29	1.14	1.60	33
June 15	do	16	.41	1.08	6.6
July 22	do	3.1	1.26	1.04	3.9
August 10	do	3	1.43	1.04	4.3
September 24	H. K. Barrows	17	1.04	1.41	18
October 13	T. W. Norcross	17	.75	1.32	12

Mean daily gage height, in feet, of Israel River (above South Branch) near Jefferson Highlands, N. H., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.20	0.80	0.80	1.40	2.35	1.35	1.10	1.20	1.10	1.60	1.45	1.20
2	1.20	.80	.80	1.30	2.00	1.30	1.10	1.18	1.32	1.60	1.45	1.20
3	1.10	.80	.80	1.30	1.90	1.40	1.45	1.30	1.60	1.60	1.40	1.20
4	1.05	.78	.80	1.30	2.10	1.35	1.45	1.30	1.55	1.50	1.35	1.20
5	1.00	.78	.80	1.30	2.10	1.30	1.30	1.20	1.50	1.50	1.35	1.18
6	[a] 1.00	.78	.80	1.25	2.00	1.30	1.25	1.15	1.40	1.60	1.35	1.18
7	.90	1.80	.80	1.65	2.10	1.45	1.20	1.10	1.40	1.60	1.30	1.18
8	.90	2.50	.80	1.60	2.10	1.40	1.15	1.05	1.35	1.60	1.30	1.15
9	.85	2.80	.80	1.50	2.00	1.35	1.10	1.00	1.30	1.55	1.25	1.15
10	.85	3.00	.80	1.50	1.90	1.30	1.05	1.00	1.30	1.50	1.25	1.15
11	.85	2.50	.80	1.50	2.35	1.25	1.00	1.05	1.25	1.50	1.20	1.12
12	.85	1.50	.80	1.50	1.80	1.20	.95	1.10	1.20	1.40	1.20	1.12
13	.82	1.30	.80	1.70	1.70	1.15	1.20	1.35	1.15	1.35	1.20	1.10
14	.82	1.10	2.00	1.70	1.70	1.15	1.10	1.30	1.15	1.30	1.60	1.10
15	.82	1.00	3.20	1.50	1.65	1.12	1.08	1.62	2.15	1.30	1.80	1.10
16	.80	1.00	3.00	1.45	2.00	1.12	1.05	1.55	1.60	1.30	1.40	1.10
17	.80	.95	2.70	1.40	3.20	1.10	1.00	1.50	1.60	1.30	1.60	1.10
18	.80	.92	2.40	1.40	2.10	1.10	.98	1.40	1.30	1.30	1.50	[b]
19	.80	.90	3.20	1.45	2.25	1.05	.98	1.30	1.20	1.28	1.40	.....
20	.80	.88	4.30	1.45	2.30	1.00	.98	1.25	1.70	1.28	1.60	.....
21	.80	.88	4.00	1.50	2.00	.95	.98	1.68	1.60	1.28	1.60	.....
22	.80	.88	3.40	1.50	2.00	1.35	.95	1.62	1.60	1.25	1.50	.....
23	.80	.88	3.00	1.60	1.80	1.25	.95	1.60	1.50	2.00	1.40	.....
24	.80	.85	4.40	1.68	1.75	1.25	.98	1.55	1.40	1.90	1.20	.....
25	.80	.85	4.80	2.70	1.60	1.30	1.00	1.50	1.60	1.80	1.20	.....
26	.80	.85	4.70	1.70	1.65	1.25	1.20	1.40	1.60	1.70	1.20	.....
27	.80	.82	4.00	1.70	1.65	1.10	1.20	1.30	1.50	1.75	1.60	.....
28	.80	.82	2.00	1.90	1.55	1.10	1.15	1.20	1.40	1.70	1.60	.....
29	.80	.82	1.70	2.90	1.50	1.15	1.18	1.15	2.00	1.60	1.40	.....
30	.80	.....	1.40	2.30	1.45	1.15	1.20	1.15	1.90	1.55	1.20	.....
31	.80	.....	1.40	.....	1.40	.....	1.15	1.10	.....	1.55	.....	.....

[a] Ice 12 inches—6 solid—6 anchor.

[b] Frozen.

Rating table for Israel River (above South Branch) near Jefferson Highlands, N. H., from September 2, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.8	1.0	1.6	30	2.6	158	3.6	338
.85	1.2	1.7	38	2.7	176	3.7	356
.9	1.6	1.8	46	2.8	194	3.8	374
.95	2.2	1.9	55	2.9	212	3.9	392
1.0	3.0	2.0	67	3.0	230	4.0	410
1.1	5.3	2.1	79	3.1	248	4.2	446
1.2	8.6	2.2	93	3.2	266	4.4	482
1.3	13	2.3	108	3.3	284	4.6	518
1.4	18	2.4	124	3.4	302	4.8	554
1.5	24	2.5	140	3.5	320		

The foregoing table is applicable only for open-channel conditions. It is based upon discharge measurements made during 1903 and 1904. It is fairly well defined between gage heights 1.04 feet and 2.40 feet. The table has been extended beyond these limits. Above gage height 2.50 feet the rating curve is a tangent, the difference being 18 per tenth.

Estimated monthly discharge of Israel River (above South Branch) near Jefferson Highlands, N. H., for 1903 and 1904.

[Drainage area, 8.7 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1903.					
September 2–30	8.6	4.8	6.09	0.700	0.755
October	29	4.8	9.26	1.07	1.23
November 1–17	17	4.8	8.70	1.00	.632
1904.					
March 14–31	554	18	259	29.77	19.93
April	212	13	39	4.48	5.00
May	266	18	66	7.59	8.75
June	21	2.2	10.1	1.16	1.29
July	21	2.2	6.46	.743	.857
August	36	3.0	14.3	1.64	1.89
September	86	5.3	24.7	2.84	3.17
October	67	10.6	26.4	3.03	3.49
November	30	8.6	17.5	2.01	2.24
December 1–17	8.6	5.3	6.85	.787	.498

NOTE.—Ice conditions November 18, 1903, to March 13, 1904, and December 18–31, 1904.

ISRAEL RIVER (BELOW SOUTH BRANCH) NEAR JEFFERSON HIGHLANDS, N. H.

This station was established September 2, 1903, by N. C. Grover. It is located at a small wooden highway bridge about 2 miles from the railway station at Jefferson Highlands, in the town of Jefferson. The drainage basin at this point is 21.2 square miles. South Branch of Israel River has its mouth above this station and below the station previously described. South Branch drains an area of 10.5 square miles; its headwaters are on the slopes of Mount Jefferson and Mount Dartmouth, at elevations of 3,000 to 5,000 feet. The extreme length from its source to its mouth is about 5 miles. The elevation at its mouth is about 1,350 feet. As all the slopes are steep there is little or no storage of water. The underlying rock is granite, exposed in

the mountain peaks. The basin has been generally "hard cut," as the lumbermen say, but has not been burned.

A standard chain gage is attached to the downstream side of the truss of the bridge; length of chain, 12.99 feet. It is referred to bench marks as follows: (1) Marked point on center cross timber of bridge; elevation, 8.14 feet. (2) Top of bowlder 50 feet north of bridge, 15 feet west of highway; elevation, 5.20 feet. Elevations are above datum of gage. The channel is straight for 100 feet above and 100 feet below the station, and is about 20 feet wide. The bed is rough and rocky, but permanent. The banks are subject to overflow in extreme freshets. At extreme low water the mean velocity observed was 0.79 feet per second. Depths average at low water about 1 foot. Gage is read once daily by E. A. Crawford, of Jefferson Highlands.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Israel River (below South Branch) near Jefferson Highlands, N. H., in 1903 and 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Square feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
September 2	H. K. Barrows	13.3	1.35	1.13	17.9
September 18	do	12.3	1.21	1.10	14.9
October 9	N. C. Grover	10.4	1.11	1.03	11.5
1904.					
April 16	N. C. Grover	16	2.55	1.43	42
April 18	do	18	2.87	1.49	52
April 30	S. K. Clapp	64	4.75	2.55	304
May 1	do	54	4.29	2.28	232
May 11	do	57	4.80	2.40	273
May 25	do	24	3.33	1.64	80
June 15	do	12	1.25	1.09	15
July 22	do	10.4	.79	.94	8.2
August 10	do	11.5	.82	1.00	9.4
September 24	H. K. Barrows and T. W. Norcross.	18.5	1.99	1.40	36.8
October 13	T. W. Norcross	17	1.63	1.36	28
November 18	do	27	.89	1.98	24

Mean daily gage height, in feet, of Israel River (below South Branch) near Jefferson Highlands, N. H., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.60	0.85	0.85	1.40	2.35	1.35	1.10	1.20	1.10	1.60	1.45	1.80
2	1.40	.85	.85	1.35	2.00	1.30	1.10	1.15	1.30	1.60	1.45	1.70
3	1.10	.82	.82	1.35	1.90	1.40	1.45	1.30	1.60	1.60	1.40	1.60
4	1.08	.82	.82	1.35	2.10	1.35	1.40	1.30	1.50	1.60	1.35	1.60
5	1.00	.82	.82	1.30	2.10	1.30	1.30	1.20	1.50	1.50	1.35	1.40
6	[a] 1.00	.82	.82	1.30	1.90	1.30	1.25	1.10	1.45	1.50	1.35	1.20
7	.95	[b] 1.90	.82	1.70	2.10	1.45	1.20	1.05	1.45	1.60	1.30	1.20
8	.92	2.70	.80	1.60	2.00	1.40	1.15	1.05	1.40	1.60	1.30	1.20
9	.90	3.30	.80	1.60	1.90	1.35	1.10	1.00	1.35	1.55	1.30	1.15
10	.90	3.00	.80	1.50	1.90	1.30	1.05	1.00	1.30	1.50	1.28	1.15
11	.90	2.10	.80	1.50	2.40	1.25	1.00	1.10	1.25	1.50	1.25	1.15
12	.90	1.20	.80	1.50	1.85	1.20	.95	1.10	1.20	1.40	1.25	1.15
13	.88	1.20	.80	1.70	1.75	1.15	1.20	1.30	1.15	1.35	1.22	1.15
14	.88	1.10	2.40	1.70	1.70	1.15	1.10	1.20	1.15	1.30	1.65	1.15
15	.88	1.00	3.50	1.50	2.05	1.12	1.08	1.60	2.22	1.30	1.40	1.15
16	.85	1.00	3.40	1.45	2.10	1.12	1.05	1.50	1.60	1.28	1.20	1.15
17	.85	.90	3.00	1.40	3.25	1.10	1.00	1.40	1.60	1.28	1.60	1.15
18	.85	.90	3.70	1.40	2.05	1.10	.98	1.30	1.35	1.28	1.95	[c]
19	.85	.90	3.70	1.45	2.30	1.05	.98	1.20	1.20	1.25	1.90	.....
20	.85	.90	3.70	1.45	2.35	1.00	.98	1.15	1.70	1.25	1.60	.....
21	.85	.90	4.40	1.50	2.10	.95	.98	1.70	1.60	1.25	1.40	.....
22	.85	.88	4.20	1.50	2.00	1.35	.95	1.60	1.50	2.00	1.20	.....
23	.85	.88	3.70	1.60	1.80	1.30	.95	1.60	1.40	2.00	1.20	.....
24	.85	.88	3.00	1.70	1.70	1.25	.98	1.50	1.40	1.92	1.20	.....
25	.86	.88	4.70	2.70	1.65	1.30	1.00	1.40	1.60	1.85	1.20	.....
26	.85	.85	5.20	1.90	1.65	1.25	1.20	1.30	1.60	1.70	1.30	.....
27	.85	.85	5.00	1.80	1.75	1.15	1.20	1.25	1.50	1.70	1.60	.....
28	.85	.85	4.00	1.90	1.55	1.15	1.10	1.20	1.40	1.60	1.90	.....
29	.85	.85	2.20	2.70	1.50	1.10	1.30	1.15	2.05	1.50	1.90	.....
30	.85	.....	1.70	2.30	1.45	1.10	1.20	1.15	1.90	1.50	1.90	.....
31	.85	.....	1.40	.....	1.40	.....	1.15	1.10	.....	1.48	.....	.....

[a] Ice, 14 inches—8 in solid and 6 in anchor ice. [b] Anchor ice affects gage heights. [c] Frozen.

Rating table for Israel River (below South Branch) near Jefferson Highlands, N. H., from September 2, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.8	2.5	1.35	35	2.4	268	3.5	576
.85	3.7	1.4	40	2.5	296	3.6	604
.9	5.3	1.5	52	2.6	324	3.7	632
.95	7.4	1.6	67	2.7	352	3.8	660
1.0	10	1.7	86	2.8	380	4.0	716
1.05	13	1.8	108	2.9	408	4.2	772
1.1	16	1.9	132	3.0	436	4.4	828
1.15	19	2.0	157	3.1	464	4.6	884
1.2	22	2.1	184	3.2	492	4.8	940
1.25	26	2.2	212	3.3	520	5.0	996
1.3	30	2.3	240	3.4	548	5.2	1,052

The foregoing table is applicable only for open-channel conditions. It is based upon discharge measurements made during 1903 and 1904. It is well defined between gage heights 0.94 foot and 2.60 feet. The table has been extended beyond these limits. Above gage height 2.10 feet the rating curve is a tangent, the difference being 28 per tenth.

Estimated monthly discharge of Israel River (below South Branch) near Jefferson Highlands, N. H., for 1903 and 1904.

[Drainage area, 21.2 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1903.					
September 2–30	22	7	12.7	0.599	0.646
October	59	10	17.0	.802	.925
November 1–17	30	13	17.7	.835	.528
1904.					
March 14–31	1,052	40	578	27.26	18.25
April	352	30	86.5	4.08	4.55
May	506	40	152	7.17	8.27
June	46	7.4	25.0	1.18	1.32
July	46	7.4	17.4	.821	.946
August	86	10	30.4	1.43	1.65
September	218	16	57.4	2.71	3.02
October	157	26	62.3	2.94	3.39
November	144	22	53.3	2.51	2.80
December 1–17	108	19	35.6	1.68	1.06

NOTE.—Ice conditions November 18, 1903, to March 13, 1904, and December 18 to 31, 1904.

AMMONOOSUC RIVER AT BRETTON WOODS, N. H.

This station was established August 28, 1903, by N. C. Grover. It is located at the steel highway bridge near Mount Pleasant House at Bretton Woods. The drainage area at this point is 34 square miles. The headwaters of the river come from the westerly slopes of Mount Jefferson and Mount Washington and the lesser peaks of the White Mountains lying to the south. The underlying rock is granite, which is exposed at points in the river bed and on the various mountain summits. The slopes and valleys are usually well forested, with a preponderance of evergreen growth. The area was cut in large part for spruce several years ago, but now has a thick forest cover. There is no pondage or artificial storage. The slope of the river is steep.

A standard chain gage is attached to the floor on the downstream side of the bridge; length of chain, 18.86 feet. It is referred to the

following-described bench marks: (1) Marked point on bridge near gage; elevation, 17.36 feet. (2) Northwest corner of east abutment; elevation, 14.46 feet. (3) Top of bowlder 100 feet below bridge, between the river and tracks of Boston and Maine Railroad; elevation, 17.11 feet. Elevations are above datum of gage. Measurements of flow are made from a footbridge located about 300 feet downstream from the gage. The channel is straight for 300 feet above and 200 feet below this bridge, and is about 35 feet wide. The banks are high and not subject to overflow except in extreme freshet. The bed is somewhat rocky, but permanent. Low-water measurements are made by wading about 100 feet above the station, on account of small velocity at the station.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Ammonoosuc River at Bretton Woods, N. H., in 1903 and 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Square feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
August 28	H. K. Barrows	69.2	0.65	1.65	45
September 2	do	62.0	.50	1.50	31
September 3	do	63.5	.46	1.48	29
September 17	do	45.4	.34	1.26	15
September 17	do	32.0	.49	1.26	16
October 10	N. C. Grover	61.8	.65	1.64	40
1904.					
April 15	N. C. Grover	94	.95	2.00	89
May 2	S. K. Clapp	166	2.81	3.20	467
May 9	do	175	3.62	3.47	634
May 10	do	175	3.58	3.51	627
May 20	do	167	2.99	3.15	499
May 25	do	91	1.35	2.19	123
June 10	do	66	.65	1.60	43
July 21 [a]	do	16	1.12	1.24	18
August 9 [b]	do	17	1.36	1.30	23
August 23	H. K. Barrows	82	.82	1.89	67
August 24 [c]	do	25	1.76	1.67	44
September 25	H. K. Barrows and T. W. Norcross.	94	1.25	2.26	118
October 11	T. W. Norcross	79	.78	1.84	62
November 17	do	62	.46	1.51	28

[a] Measured 400 feet above gage.
[b] Measured 300 feet above gage.
[c] Wading below gage.

Mean daily gage height, in feet, of Ammonoosuc River at Bretton Woods, N. H., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.55	.....	.....	1.85	3.78	1.88	1.40	1.40	1.35	2.75	1.85	1.50
2	1.50	.....	.....	1.90	3.20	1.75	1.78	1.38	1.48	2.55	1.80	1.55
3	.....	.....	2.10	1.90	2.90	1.75	2.02	1.58	1.48	2.40	1.80	1.55
4	1.55	.....	.....	1.90	3.30	1.70	1.65	1.50	1.90	2.20	1.80	1.55
5	.....	.....	1.88	1.88	3.45	1.70	1.62	1.38	1.58	2.10	1.80	1.52
6	.....	[a]1.40	.....	1.95	2.95	1.70	1.50	1.40	1.50	2.20	1.78	1.50
7	.....	.....	1.70	2.10	3.10	1.72	1.42	1.38	1.48	2.08	1.80	1.50
8	.....	.....	.....	2.60	3.18	1.78	1.38	1.32	1.45	1.72	1.72	1.50
9	1.50	.....	.....	3.35	2.90	1.68	1.35	1.30	1.42	1.90	1.70	[b]1.45
10	1.50	.....	.....	4.25	3.32	1.60	1.35	1.30	1.40	1.90	1.70	.....
11	1.45	.....	[c]1.75	2.95	3.50	1.55	1.35	1.48	1.38	1.82	1.58	.....
12	1.45	.....	[c]1.75	2.55	2.92	1.50	1.35	1.68	1.35	1.78	1.58	.....
13	1.45	[d]1.35	.....	2.35	2.78	1.50	1.45	1.55	1.40	1.80	1.55	.....
14	1.40	.....	.....	2.05	2.60	1.48	1.38	1.50	1.40	1.80	1.55	.....
15	.....	.....	1.50	2.00	2.92	1.45	1.30	1.75	3.15	1.78	1.55	.....
16	.....	.....	1.50	1.80	3.85	1.42	1.30	1.48	2.20	1.75	1.62	.....
17	1.40	.....	1.55	1.90	4.22	1.40	1.30	1.40	1.80	1.70	1.65	[g]1.40
18	.....	.....	.....	2.00	2.98	1.40	1.30	1.40	1.80	1.70	1.60	.....
19	.....	[e]1.40	1.50	2.10	3.35	1.35	1.28	1.35	2.15	1.68	1.58	.....
20	.....	.....	.....	2.10	3.20	1.35	1.25	1.92	1.82	1.65	1.52	.....
21	.....	.....	1.50	2.00	2.82	1.35	1.25	2.30	2.70	3.55	1.58	.....
22	.....	2.50	1.55	2.00	2.58	2.02	1.25	1.82	2.25	3.05	1.60	.....
23	2.10	2.40	2.15	2.02	2.45	1.65	1.25	1.95	1.85	2.48	1.60	.....
24	2.20	2.32	2.40	2.48	2.32	1.48	1.25	1.70	1.92	2.25	1.55	1.35
25	.....	2.15	3.05	3.25	2.22	1.40	1.25	1.58	2.12	2.20	1.50	.....
26	.....	.....	7.60	2.82	2.18	1.68	1.30	1.52	2.00	2.28	1.52	.....
27	.....	[f]1.50	4.02	3.05	2.25	1.48	1.60	1.50	1.92	2.32	1.62	.....
28	.....	.....	2.32	3.30	2.08	1.45	1.35	1.42	1.82	2.20	1.50	.....
29	1.60	.....	2.00	3.95	1.95	1.40	1.45	1.40	1.90	2.35	1.50	.....
30	.....	.....	2.00	3.75	1.90	1.40	1.42	1.40	2.90	2.00	1.50	.....
31	.....	.....	1.85	.....	1.85	.....	1.35	1.35	.....	1.98	.....	[h]1.30

[a] Ice 0.65 foot thick. [c] Ice 0.5 foot thick. [e] Ice 0.9 foot thick. [g] Ice 0.6 foot thick.
[b] Ice 0.15 foot thick. [d] Ice 0.85 foot thick. [f] Ice 0.4 foot thick. [h] Ice 0.75 foot thick.

NOTE.—Gage heights during frozen season are to surface of water in hole cut in ice under gage. Ice January 1 to March 25, also December 10–31.

Rating table for Ammonoosuc River at Bretton Woods, N. H., from August 28, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.25	15	1.8	58	2.7	238	3.8	820
1.3	18	1.85	63	2.8	277	3.9	880
1.35	21	1.9	68	2.9	318	4.0	940
1.4	24	1.95	74	3.0	365	4.2	1,060
1.45	27	2.0	80	3.1	415	4.4	1,180
1.5	31	2.1	93	3.2	465	4.6	1,300
1.55	35	2.2	108	3.3	520	4.8	1,420
1.6	39	2.3	125	3.4	580	5.0	1,540
1.65	43	2.4	146	3.5	640	5.5	1,840
1.7	48	2.5	172	3.6	700	6.0	2,140
1.75	53	2.6	203	3.7	760		

The foregoing table is applicable only for open-channel conditions. It is based upon 21 discharge measurements made during 1903 and 1904. It is fairly well defined between gage heights 1.25 feet and 3.50 feet. The table has been extended beyond these limits. Above gage height 3.30 feet the rating curve is a tangent, the difference being 60 per tenth.

Estimated monthly discharge of Ammonoosuc River at Bretton Woods, N. H., for 1903 and 1904.

[Drainage area, 34 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1903.					
September	35	17	23.3	0.685	0.764
October	203	21	42.5	1.25	1.44
November	86	18	34.1	1.00	1.12
December 1–14	96	18	27.0	.794	.413
1904.					
March 26–31	3,100	63	734	21.59	4.82
April	1,090	58	245	7.21	8.04
May	1,072	63	362	10.65	12.28
June	82	21	37.5	1.10	1.23
July	82	15	25.5	.750	.865
August	125	18	35.6	1.05	1.21
September	440	21	80.5	2.37	2.64
October	670	43	123	3.62	4.17
November	63	31	42.5	1.25	1.40
December 1–9	35	27	32.1	.944	.316

ZEALAND RIVER NEAR TWIN MOUNTAIN, N. H.

This gaging station was established August 29, 1903, by N. C. Grover. It is located about 800 feet above the mouth of the river, which empties into the Ammonoosuc at a point midway between Fabyans and Twin Mountain, and about 2½ miles from either place. The drainage basin at this point has an area of 14 square miles. The headwaters lie on the slopes of a spur of the White Mountains at elevations of 2,500 to 3,000 feet. The length of the river from its headwaters to its mouth is about 7 miles, at which point the elevation is approximately 1,500 feet. All slopes within the basin are steep. There is no pondage or artificial storage of water. The underlying rock is granite, which is exposed in the mountain peaks. About ten or twelve years ago this basin was entirely deforested and burned over. At the present time

there is a thick stand of deciduous growth of poplar and bird cherry, averaging 12 to 15 feet in height, which affords a thick covering during the summer months, but practically no cover during the winter and spring. Within the basin we find the usual conditions of this stage of reforestation after a thorough burning.

A standard chain gage is attached to trees on the bank; length of chain, 13.40 feet. It is referred to bench marks as follows: (1) Top of large bowlder under the gage; elevation, 3.56 feet. (2) Drift bolt driven into the maple tree to which the gage is attached; elevation, 11.32 feet. Elevations are above datum of gage. The lowest observed mean velocity has been 0.40 of a foot per second. Low-water measurements are made by wading. The bed is rough and rocky, but permanent. The banks are high and only subject to overflow in extreme freshets. The gage is read once a day by William Cote, of Twin Mountain.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Zealand River near Twin Mountain, N. H., in 1903 and 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Square feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
August 29[a]	H. K. Barrows	29.1	0.45	2.01	13.1
September 3[a]	do	26.6	.40	1.98	10.7
September 18[a]	do	33.5	.68	2.22	22.9
October 10[a]	N. C. Grover	35.5	.76	2.29	27
1904.					
April 15	N. C. Grover	25.3	1.88	2.52	47.5
April 30	S. K. Clapp	79	4.09	3.55	323
May 10	do	56	3.25	3.00	182
May 19	do	80	4.60	3.60	368
May 20	do	54	3.37	3.08	182
May 25	do	21	2.10	2.49	44
June 10	do	10	2.10	2.18	21
July 21	do	6.8	1.12	1.88	7.6
August 9	do	8.4	1.49	1.94	12.5
August 23[a]	H. K. Barrows	40	.95	2.39	38
September 25[a]	do T. W. Norcross	46	1.48	2.65	68
October 12	do	33	.69	2.21	23

[a] Wading at different sections.

Mean daily gage height, in feet, of Zealand River near Twin Mountain, N. H., for 1904.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	(a)	2.40	3.50	2.40	1.84	1.84	1.74	4.34	3.25	2.35
2	.....	2.45	3.40	2.40	1.84	1.84	1.94	4.14	3.35	2.45
3	.....	2.30	3.30	2.30	1.74	1.94	1.94	3.44	2.85	2.45
4	.....	2.30	3.10	2.20	1.74	1.94	1.84	2.84	2.75	2.75
5	.....	2.40	3.00	2.20	1.74	2.04	1.84	3.04	2.75	2.75
6	.....	2.40	3.00	2.10	1.74	1.84	2.04	2.84	2.65	2.55
7	.....	2.50	2.90	2.10	1.74	1.84	2.04	2.84	2.85	(a)
8	.....	2.70	2.70	2.10	1.84	1.94	1.94	2.74	2.85	.....
9	.....	2.70	2.60	2.00	1.84	1.84	1.94	2.44	2.65	.....
10	.....	3.00	2.60	2.10	1.74	1.84	1.84	2.64	2.75	.....
11	.....	3.20	2.70	2.10	1.74	1.84	1.84	2.84	2.75	.....
12	.....	3.00	2.70	2.10	1.94	1.84	1.94	2.84	2.65	.....
13	.....	2.90	2.60	2.05	1.94	1.74	1.94	2.64	2.85	.....
14	.....	2.80	2.70	2.00	1.84	1.74	4.34	2.34	2.75	.....
15	.....	2.70	2.50	2.00	1.84	1.84	3.24	2.24	2.85	.....
16	.....	2.60	2.50	2.00	1.84	1.84	2.84	2.24	2.85	.....
17	.....	2.45	2.80	1.95	1.84	1.74	2.84	2.94	2.65	.....
18	.....	2.40	3.00	2.00	1.74	1.94	2.24	2.84	2.65	.....
19	.....	2.40	2.90	2.00	1.84	1.94	1.84	2.74	2.65	.....
20	.....	2.40	2.70	2.00	1.84	1.84	2.24	1.94	2.85	.....
21	.....	2.30	2.70	2.00	1.84	2.84	2.84	3.84	2.95	.....
22	.....	2.30	2.50	1.90	1.94	2.24	2.64	4.34	2.95	.....
23	.....	2.40	2.50	2.10	1.94	2.44	2.34	3.84	2.85	.....
24	.....	2.50	2.40	2.10	1.84	2.24	2.34	3.74	2.85	.....
25	.....	2.60	2.40	2.00	1.74	1.94	2.64	3.74	2.85	.....
26	.....	2.60	2.40	1.90	1.84	1.84	3.84	3.34	2.65	.....
27	3.00	2.70	2.40	1.90	2.34	1.84	2.84	3.24	2.75	.....
28	2.70	3.00	2.50	1.90	2.14	1.84	2.84	2.84	2.75	.....
29	2.50	4.00	2.40	1.90	1.94	1.94	2.64	2.84	2.55	.....
30	2.50	3.70	2.40	1.90	1.94	1.94	2.24	3.24	2.35	.....
31	2.40	.....	2.30	.....	1.84	1.84	.....	3.24	.....	.....

a River frozen January 1 to March 26 and December 7-31.

Rating table for Zealand River near Twin Mountain, N. H., from August 29, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.75	4	2.2	22	2.7	82	3.6	368
1.8	5	2.25	25	2.8	109	3.7	402
1.85	6	2.3	28	2.9	139	3.8	436
1.9	8	2.35	31	3.0	170	3.9	470
1.95	10	2.4	35	3.1	202	4.0	504
2.0	12	2.45	40	3.2	234	4.1	538
2.05	14	2.5	45	3.3	266	4.2	572
2.1	16	2.55	52	3.4	300	4.3	606
2.15	19	2.6	61	3.5	334		

The above table is applicable only for open-channel conditions. It is based upon 16 discharge measurements made during 1903 and 1904. It is well defined between gage heights 1.88 feet and 3.60 feet. The table has been extended beyond these limits. Above gage height 3.30 feet the rating curve is a tangent, the difference being 34 per tenth.

Estimated monthly discharge of Zealand River near Twin Mountain, N. H., for 1903 and 1904.

[Drainage area, 14 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1903.					
September	22	8	10.5	0.750	0.837
October	35	8	17.8	1.27	1.46
November	28	16	23.6	1.69	1.89
December 1–28	45	16	29.0	2.07	2.16
1904.					
March 27–31	170	35	75.4	5.39	1.00
April	504	28	97.9	6.99	7.80
May	334	28	101	7.21	8.31
June	35	8	15.0	1.07	1.19
July	30	4	7.35	.525	.605
August	121	4	13.0	.929	1.07
September	620	4	76.4	5.46	6.09
October	620	10	213	15.21	17.54
November	283	31	119	8.50	9.48
December 1–6	95	31	58.8	4.20	.937

LITTLE RIVER NEAR TWIN MOUNTAIN, N. H.

This station was established January 21, 1904, by F. E. Pressey. It is located at the rough wooden highway bridge about 2 miles southwest of Twin Mountain, N. H., and about 2 miles above the entrance of this river into Ammonoosuc River. The drainage area at this point is about 11 square miles. This drainage basin is adjacent to that of Zealand River previously described, and practically all forest cover has been removed from it. The slopes are steep and there is no pondage or artificial storage. This station was established in order to obtain comparative data as to the time and duration of freshets. A few discharge measurements have been made during 1904, but it is not intended to make any estimate of discharge for this point, but merely a record of gage heights.

A standard chain gage is attached to the floor on the downstream side of the bridge above referred to; length of chain, 12.92 feet. It is referred to bench marks as follows: (1) A marked point on the floor of the bridge near the zero of the gage scale; elevation, 11.42 feet above gage datum; (2) a cross on a bowlder on right bank, about 32 feet from end of gage box; elevation, 9.05 feet above gage datum.

The channel is straight for about 50 feet above and 800 feet below the station. The banks are rocky, low, and clean, and liable to overflow. The bed of the stream is of large bowlders and extremely rough. The current is swift at all stages. The gage is read twice daily by Edward Lynch.

Observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Little River near Twin Mountain, N. H., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Square feet.	*Ft. per sec.*	*Feet.*	*Second-feet.*
August 23 [a]	H. K. Barrows	26	2.04	5.58	53
September 25 [a]	H. K. Barrows and T. W. Norcross.	32	2.06	5.75	66
October 12 [b]	T. W. Norcross	28	.94	5.30	26

[a] Wading 1 mile below gage. [b] Wading.

Mean daily gage height, in feet, of Little River near Twin Mountain, N. H., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	4.60	4.70	4.90	6.15	5.20	4.90	5.20	5.00	6.05	5.20	5.10
2	.....	4.65	4.60	4.90	5.70	5.10	5.10	5.05	5.00	5.75	5.20	5.10
3	.....	4.60	5.00	4.90	5.85	5.05	5.35	5.15	5.10	5.65	5.20	5.10
4	.....	4.60	5.85	4.95	6.00	5.10	5.00	5.10	5.30	5.55	5.20	5.10
5	.....	4.65	5.05	5.05	6.10	5.00	5.00	5.10	5.15	5.45	5.20	5.10
6	.....	4.60	4.70	5.05	6.10	5.10	5.00	5.10	5.10	5.55	5.15	5.10
7	.....	5.10	4.65	5.45	6.05	5.00	4.95	5.00	5.10	5.45	5.10	5.10
8	.....	6.05	7.20	5.65	6.00	5.00	4.90	5.00	5.10	5.40	5.10	5.10
9	.....	4.80	5.00	6.15	6.00	5.00	4.90	5.00	5.10	5.35	5.10	5.10
10	.....	4.70	4.95	6.20	5.85	5.00	4.90	5.00	5.00	5.30	[a] 5.25	5.10
11	.....	4.60	4.80	5.80	6.20	5.00	4.90	5.10	5.00	5.30	5.25	5.10
12	.....	4.60	4.80	5.50	5.90	4.90	4.90	5.15	5.00	5.30	5.20	5.10
13	.....	4.60	4.70	5.45	5.85	4.90	5.25	5.10	5.00	5.30	5.10	.....
14	.....	4.60	4.70	5.40	5.85	4.95	5.05	5.00	5.00	5.30	5.10	.....
15	.....	4.60	4.70	5.35	5.95	5.00	5.00	5.20	6.60	5.20	5.10	.....
16	.....	4.60	4.70	5.30	6.50	5.00	5.00	5.10	5.85	5.20	5.10	.....
17	.....	4.60	4.70	5.35	6.25	5.00	4.90	5.10	5.50	5.20	5.10	.....
18	.....	4.60	4.70	5.15	6.05	4.95	4.90	5.10	5.35	5.20	5.40	.....
19	.....	4.60	4.70	5.00	6.20	4.90	4.90	5.00	5.75	5.20	5.45	.....
20	.....	4.60	4.60	5.40	6.15	4.90	4.90	5.90	5.40	5.20	5.15	.....
21	4.65	4.60	4.60	5.15	5.90	4.90	4.80	5.85	5.95	6.20	5.25	.....
22	4.65	6.20	4.65	5.40	5.80	5.05	4.80	5.55	5.55	6.10	5.10	.....
23	5.05	5.00	6.85	5.15	5.70	5.00	4.80	5.75	5.45	5.90	5.10	.....
24	4.85	4.65	5.50	5.35	5.65	5.00	4.80	5.35	5.50	5.55	5.10	.....
25	4.70	4.60	5.70	5.95	5.60	4.90	4.90	5.30	5.75	5.50	5.10	.....
26	4.70	4.60	6.45	5.75	5.60	4.90	4.90	5.25	5.55	5.65	5.10	.....
27	4.70	4.70	5.40	5.55	5.55	4.90	5.10	5.15	5.45	5.55	5.20	.....
28	4.70	4.70	5.25	5.55	5.45	4.90	5.10	5.10	5.40	5.35	5.10	.....
29	4.65	4.70	5.15	6.00	5.30	4.90	5.45	5.10	5.45	5.30	5.40	.....
30	4.60	.....	5.20	6.10	5.25	4.90	5.15	5.05	6.05	5.25	5.10	.....
31	4.60	.....	5.10	.....	5.20	.....	5.00	5.00	.....	5.20	.....	.....

[a] After November 10 gage heights probably affected by anchor ice.

WHITE RIVER AT SHARON, VT.

This station was established June 30, 1903, by H. K. Barrows. It is located at the steel highway bridge near the railway station at Sharon. The drainage area at this point is 680 square miles. A standard chain gage is attached to the upstream truss of the bridge; length of chain, 27.58 feet. It is referred to bench marks as follows: (1) Marked point on post near gage; elevation, 29.96 feet; (2) on south side of east abutment; elevation, 24.59 feet. Elevations are above datum of gage. This station is located above and within the backwater from a crib dam, which is not used for power purposes, all water, except leakage, passing over the crest of the dam. The channel is straight for 500 feet above and 500 feet below the station. It is about 170 feet wide at ordinary stages. The current is sluggish at low water. Measurements at low stages are made by wading at a point about one-half mile above the bridge, where the bed is of gravel and the current swift. The gage is read twice daily by J. M. O'Connor, of Sharon.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of White River at Sharon, Vt., in 1903 and 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Square feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
June 30	H. K. Barrows	1,580	0.28	5.03	440
August 1 [a]	do	170	2.32	4.87	395
September 10 [a]	do	140	1.93	4.79	270
1904.					
April 7	N. C. Grover	1,840	1.69	6.63	3,110
May 3	S. K. Clapp	1,820	1.54	6.49	2,810
May 27	do	1,710	.69	5.58	1,180
July 7 [a]	do	62	2.37	4.51	147
July 7 [a]	do	52	2.46	4.49	128
July 27 [a]	do	86	3.67	4.70	316
September 26	T. W. Norcross	1,690	.75	5.59	1,260

[a] By wading.

Mean daily gage height, in feet, of White River at Sharon, Vt., for 1904.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	6.20	7.20	5.20	4.75	4.50	4.50	5.90	6.15	.....
2	.....	6.15	6.80	5.20	4.80	4.50	4.40	5.90	6.05	.....
3	.....	.....	6.50	5.15	4.80	4.60	4.40	5.95	5.90	.....
4	.....	.....	6.40	5.10	4.70	4.60	4.45	5.85	5.75	.....
5	.....	.....	6.20	5.15	4.70	4.65	4.70	5.75	5.65	.....
6	.....	.....	6.00	5.20	4.60	4.65	4.80	5.65	5.75	.....
7	.....	6.80	5.80	5.10	4.55	4.70	4.90	5.55	5.85	.....
8	.....	6.80	5.70	5.10	4.50	4.70	4.95	5.45	5.90	.....
9	.....	7.70	5.65	5.05	4.50	(a)	4.95	5.35	5.85	.....
10	.....	7.60	5.80	5.00	4.60	.....	4.90	5.25	5.75	.....
11	.....	7.20	5.80	5.00	4.60	.....	4.80	5.15	5.65	.....
12	.....	6.85	5.65	4.90	4.60	.....	4.80	5.05	5.55	.....
13	.....	6.70	5.70	4.90	4.70	.....	4.70	4.95	(b)	.....
14	.....	6.30	5.65	4.90	4.70	.....	4.70	4.85	.....	.....
15	.....	6.10	5.70	4.80	4.70	.....	4.60	4.80	.....	.....
16	.....	6.10	5.85	4.80	4.60	.....	5.90	4.85	.....	.....
17	.....	5.90	5.60	4.75	4.60	.....	5.90	4.95	.....	.....
18	.....	6.00	5.70	4.70	4.50	.....	5.85	5.05	.....	.....
19	.....	6.05	6.30	4.80	4.50	4.50	5.75	5.15	.....	.....
20	.....	6.00	6.20	4.80	4.40	4.60	5.65	5.25	.....	.....
21	.....	5.90	6.05	4.75	4.35	4.70	5.55	5.50	.....	.....
22	.....	6.00	6.05	4.75	4.30	4.80	5.45	5.80	.....	.....
23	.....	6.00	5.75	4.55	4.45	4.80	5.35	6.35	.....	.....
24	.....	6.10	5.75	4.40	4.50	4.80	5.25	6.75	.....	.....
25	.....	6.70	5.75	4.50	4.60	4.70	5.15	6.80	.....	.....
26	.....	6.75	5.70	4.50	4.70	4.70	5.40	6.70	.....	.....
27	8.05	6.40	5.60	4.40	4.70	4.60	5.60	6.65	.....	.....
28	6.80	7.30	5.45	4.45	4.70	4.60	5.60	6.55	.....	.....
29	6.35	8.10	5.40	4.55	4.60	4.60	5.65	6.45	.....	.....
30	6.25	7.85	5.30	4.60	4.60	4.60	5.80	6.35	.....	.....
31	6.30	.....	5.30	.....	4.50	4.50	.....	6.25	.....	.....

a No gage heights taken from August 9–18, inclusive, on account of repairs to dam.
b Frozen over November 13. No records during frozen season.

Rating table for White River at Sharon, Vt., from July 1, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
4.5	140	4.9	418	5.6	1,228	6.4	2,645
4.55	169	4.95	464	5.7	1,370	6.5	2,850
4.6	199	5.0	513	5.8	1,525	6.6	3,055
4.65	230	5.1	619	5.9	1,695	6.7	3,265
4.7	263	5.2	732	6.0	1,875	6.8	3,475
4.75	298	5.3	849	6.1	2,060	6.9	3,685
4.8	335	5.4	970	6.2	2,250	7.0	3,900
4.85	375	5.5	1,095	6.3	2,445		

The above table is applicable only for open-channel conditions. It is based upon 10 discharge measurements made during 1903 and 1904. It is well defined between gage heights 4.50 feet and 6.70 feet. The table has been extended beyond these limits. Below 4.50 and above 7.0 the discharge can only be considered an approximation.

Estimated monthly discharge of White River at Sharon, Vt., for 1903 and 1904.

[Drainage area, 680 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1903.					
July	1,695	263	483	0.710	0.819
August	1,967	298	510	.750	.865
September	513	230	314	.462	.516
October	921	250	471	.693	.799
November 1–21	641	320	416	.612	.478
1904.					
March 27–31	6,270	2,348	3,417	5.02	0.934
April 1–2; 7–30	6,385	1,695	3,105	4.57	4.42
May	4,335	849	1,725	2.54	2.93
June	732	88	395	.581	.648
July	335	50	200	.294	.339
August [a]	335	140	217	.319	.368
September	1,695	88	758	1.11	1.24
October	3,475	335	1,540	2.26	2.61
November 1–12	2,155	1,160	1,569	2.31	1.03

[a] August 9–18 interpolated.

ASHUELOT RIVER AT WINCHESTER, N. H.

This station was established July 10, 1903, by H. K. Barrows. It is located at the steel highway bridge in the village of Winchester. The drainage area at this point is 385 square miles. A standard chain gage is attached to the bottom chord of the upstream truss; length of chain, 25.24 feet. It is referred to bench marks as follows: (1) East end of left abutment; elevation, 20.79 feet. (2) Top of watering trough in the village square; elevation, 25.18 feet. Elevations are above datum of gage. The channel is straight for 300 feet above and 500 feet below the station, and is about 70 feet wide at ordinary stages, broken by one pier. The current is sluggish at low stages of the river, the lowest observed mean velocity having been 0.39 foot per second at gage height 4.02.

The observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Ashuelot River at Winchester, N. H., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Square feet.	*Ft. per sec.*	*Feet.*	*Second-feet.*
April 7	N. C. Grover and S. K. Clapp	734	2.35	8.57	1,720
May 16	S. K. Clapp	490	1.65	5.98	810
May 31	do	425	1.21	5.32	515
June 17	do	294	.62	4.00	181
July 8	do	297	.66	4.05	196
July 27	do	270	.45	3.62	121
August 11	do	297	.44	4.05	131

Mean daily gage height, in feet, of Ashuelot River at Winchester, N. H., for 1904.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	7.9	11.8	5.2	5.0	3.4	3.7	5.0	4.2	4.0
2	9.8	9.8	4.9	5.6	3.8	3.6	4.9	4.2	4.2
3	10.1	8.4	4.9	5.2	3.8	3.6	4.8	4.2	4.0
4	9.0	7.4	4.9	4.7	3.6	3.5	4.4	4.2	.....
5	8.2	7.0	4.6	4.6	3.9	3.4	4.4	4.2	.....
6	8.0	6.6	4.6	4.4	3.8	3.4	4.4	4.2	.....
7	8.4	6.2	5.0	4.3	3.5	3.6	4.4	4.2	.....
8	9.4	5.6	5.3	4.3	3.4	3.6	4.5	4.0	.....
9	9.9	5.7	5.3	4.4	3.5	3.6	4.5	4.1	.....
10	11.8	6.2	5.0	4.2	3.5	3.6	4.2	4.0	.....
11	12.5	6.8	4.8	4.4	4.1	4.1	4.2	3.9	.....
12	10.7	7.2	4.6	4.2	4.2	3.9	4.2	4.0	.....
13	9.4	6.7	4.5	3.8	4.2	4.1	4.1	4.1	.....
14	8.6	6.0	4.5	3.7	3.9	4.1	4.4	4.1	.....
15	7.8	5.6	4.3	3.6	3.6	5.6	4.4	4.1	.....
16	7.4	5.7	4.3	3.6	3.8	7.1	4.2	4.3	.....
17	7.2	6.0	4.2	3.4	3.8	5.4	4.1	4.2	.....
18	7.7	5.7	4.2	3.4	3.8	4.8	4.0	4.3	.....
19	7.6	5.9	4.2	3.6	3.7	4.2	4.2	4.2	.....
20	7.3	6.9	3.7	3.6	3.8	4.4	4.2	4.0	.....
21	7.0	7.2	4.1	3.5	4.4	4.5	4.1	4.1	.....
22	7.0	6.5	4.1	3.6	5.0	4.4	5.0	4.2	.....
23	6.9	6.2	4.2	3.5	4.8	4.5	5.4	4.3	.....
24	6.5	5.8	4.6	3.4	4.2	4.5	5.4	4.4	.....
25	6.6	5.5	4.2	3.4	4.0	4.5	4.8	4.5	.....
26	6.9	5.8	4.1	3.4	3.9	4.1	4.6	4.4	.....
27	6.9	5.7	4.0	3.7	3.9	4.2	4.6	4.4	.....
28	8.5	5.4	3.9	3.4	3.9	4.2	4.5	4.2	.....
29	11.2	5.1	3.9	3.5	3.6	4.2	4.2	4.2	.....
30	12.5	4.9	4.2	3.5	3.8	4.6	4.2	4.0	.....
31	.....	5.2	.....	3.4	3.7	.....	4.4	.....	.....

NOTE.—Gage not read during frozen season.

DEERFIELD RIVER AT DEERFIELD, MASS.

Deerfield River is one of the largest tributaries of Connecticut River, having a total drainage area of 667 square miles. It rises in southern Vermont, and joins Connecticut River about 1 mile southeast of Greenfield. It is important as a water-power stream, but is not well supplied with storage reservoirs, consequently subject to considerable fluctuations of flow.

A gaging station was established March 29, 1904, by N. C. Grover, at the suspension highway bridge, about one-fourth mile from West Deerfield railway station, and about 6 or 7 miles above the mouth of the river. The drainage area at this point is 550 square miles. About 2 miles below the station is an old dam, partially destroyed, and back water from Connecticut River reaches the site of this old dam. A standard chain gage is attached to the downstream side of the bridge; length of chain, 32.21 feet. The gage is referred to bench marks as follows: (1) Point on bottom chord of bridge, near the zero of gage scale; elevation, 31.49 feet. (2) On top of downstream foundation of bridge pier on the right bank; elevation, 28.92 feet. (3) Copper bolt set in ledge on left bank, 20 feet upstream from abutment; elevation, 21.04 feet. All elevations are referred to gage datum.

Discharge measurements are made from the downstream side of the bridge to which the gage is attached, the initial point for soundings being the left end of the top chord of the stiffening truss at the downstream side. The channel is straight for about 600 feet above and 1,000 feet below the station. The banks are high, rocky, and clean, and not liable to overflow. The bed is clean and permanent, the left half being of gravel and the right half of sand. There is but one channel at all stages. The current is medium, becoming sluggish at low water, when measurements are made by wading at a point about one-half mile downstream. The gage is read twice daily by Mrs. Carrie I. Wellman.

Observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Deerfield River at Deerfield, Mass., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Square feet.	*Ft. per sec.*	*Feet.*	*Second-feet.*
March 30	N. C. Grover	2,180	1.10	3.61	2,390
April 11	S. K. Clapp	2,500	2.32	4.68	5,810
April 25	do	2,480	2.02	4.58	5,010
May 18	do	2,270	1.50	3.75	3,420
June 1	do	1,920	.31	2.81	590
June 20 [a]	do	449	1.89	2.70	850
July 28 [a]	do	259	1.98	2.60	513
August 17 [a]	do	168	1.64	2.45	275
September 17	T. W. Norcross	2,015	.63	3.21	1,260
October 27	do	2,010	.49	2.90	981
November 30 [a b]	do	288	1.84	2.60	531

[a] By wading at different sections.
[b] River frozen at gage 0.1 foot thick. Gage height is to bottom of ice.

Mean daily gage height, in feet, of Deerfield River at Deerfield, Mass., for 1904.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	4.05	4.60	2.80	2.70	2.40	2.30	3.35	2.60	.....
2	.....	5.10	4.40	2.70	2.90	2.40	2.20	2.95	2.65	.....
3	.....	4.15	4.00	2.75	2.65	2.45	2.40	2.75	2.50	.....
4	.....	3.70	3.90	2.85	2.65	2.50	2.40	2.70	2.50	.....
5	.....	3.70	3.75	2.90	2.60	2.40	2.40	2.60	2.50	.....
6	.....	4.00	3.50	2.80	2.55	2.40	2.40	2.60	2.40	.....
7	.....	4.20	3.45	3.05	2.55	2.35	2.30	2.55	2.50	.....
8	.....	4.30	3.35	3.50	2.60	2.30	2.30	2.50	2.40	.....
9	.....	5.45	3.10	6.05	2.55	2.40	2.40	2.50	2.30	.....
10	.....	5.20	3.40	4.05	2.50	2.50	2.50	2.45	2.30	.....
11	.....	4.70	3.50	3.50	2.50	2.80	2.60	2.80	2.30	.....
12	.....	4.20	3.30	3.05	2.50	2.60	2.45	2.80	2.30	.....
13	.....	3.90	3.20	2.90	2.50	2.55	2.35	2.75	2.30	.....
14	.....	3.55	3.15	2.90	2.50	2.50	2.30	2.85	2.40	.....
15	.....	3.40	3.00	2.80	2.45	2.60	5.60	2.80	2.45	.....
16	.....	3.50	3.90	2.80	2.45	2.50	3.65	2.70	2.40	.....
17	.....	3.25	4.00	2.70	2.45	2.40	3.10	2.65	2.30	.....
18	.....	3.40	3.90	2.70	2.55	2.50	2.95	2.60	2.30	.....
19	.....	3.70	4.65	2.70	2.50	2.50	2.85	2.55	2.40	.....
20	.....	3.30	4.50	2.65	2.55	2.65	2.65	2.50	2.45	.....
21	.....	3.25	3.70	2.60	2.40	3.95	2.50	4.20	2.60	.....
22	.....	3.25	3.50	2.55	2.40	3.00	2.45	4.80	2.80	.....
23	.....	3.50	3.30	2.55	2.40	2.65	2.45	3.65	2.70	.....
24	.....	3.65	3.20	2.60	2.40	2.55	2.55	3.00	2.60	.....
25	.....	4.40	3.15	2.60	2.45	2.50	2.60	2.80	2.50	.....
26	.....	4.40	3.20	2.80	2.55	2.50	2.60	2.80	2.40	.....
27	.....	4.50	3.20	2.55	2.60	2.45	2.60	2.80	2.30	.....
28	.....	5.85	3.00	2.50	2.60	2.40	2.60	2.70	2.35	.....
29	3.85	5.95	2.90	2.35	2.50	2.40	2.80	2.70	2.40	.....
30	3.65	4.90	2.70	2.60	2.40	2.30	4.30	2.60	[a] 2.30	.....
31	3.65	.....	2.85	.....	2.40	2.30	.....	2.50	.....	.....

[a] River entirely frozen on November 30.

WARE RIVER NEAR WARE, MASS.

Ware River is formed in the town of Barre by the junction of several small streams. The surrounding country is hilly and largely cleared. The total drainage area is about 223 square miles, and is a tributary to Chicopee River, which drains a large section of central Massachusetts, and is the largest tributary of the Connecticut in respect to drainage area, its basin containing 730 square miles. It is formed at Three Rivers by the union in that vicinity of the Ware, Swift, and Quabog rivers; thence runs westerly about 15 miles, joining the Connecticut at Chicopee. Chicopee River and its tributaries are quite important water-power streams, and expensive developments have been made upon them.

A gaging station was established on September 15, 1904, by H. K. Barrows, at the steel highway bridge—span of about 85 feet—about 2 miles above the village of Ware. The drainage area at this point is 162 square miles. A standard chain gage is fastened to the floor timbers of the bridge on the upstream side toward the right bank; length of chain, 14.10 feet. It is referred to bench marks as follows: (1) On post of bridge railing at east end of gage; elevation, 17.01 feet. (2) On west abutment on downstream side about 18 inches from the corner near the truss; elevation, 11.48 feet. (3) Southeast corner of abutment of railroad culvert, about 250 feet north of the Boston and Maine Railroad crossing, west of gage; elevation, 18.63 feet. All bench marks are referred to gage datum.

Discharge measurements are made usually from the upstream side of the bridge to which the gage is attached. The initial point for soundings is left abutment at the top; the channel is curved for some little distance above the bridge and straight below the bridge. The bed of the stream is rocky with some gravel. The banks are medium in height and overflow at very high water, when there will be two or more channels. The current is swift at high stages and well sustained at low stages. The gage is read twice daily by M. N. Richards, a farmer. The expense of a gage reader at this point is borne equally by the Otis Company and the George H. Gilbert Manufacturing Company, both of Ware.

Observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Ware River near Ware, Mass., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Square feet.	*Ft. per sec.*	*Feet.*	*Second-feet.*
September 15 ..	H. K. Barrows.....	250	3.45	4.44	863
September 20 ..	T. W. Norcross	106	1.59	2.59	169
October 5.....	.....do	95	1.75	2.63	166
October 19.....	.....do	106	1.93	2.70	205
October 29.....	.....do	113	1.71	2.80	193
November 14 ..	.....do	89	1.49	2.46	133

Mean daily gage height, in feet, of Ware River near Ware, Mass., for 1904.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1.....	.....	2.75	2.40	2.60	17.....	3.50	2.40	2.70	.....
2.....	.....	2.50	2.75	2.60	18.....	2.75	2.35	2.50	.....
3.....	.....	2.90	2.60	2.60	19.....	2.80	2.70	2.30	.....
4.....	.....	2.85	2.65	2.10	20.....	2.55	2.50	2.00	.....
5.....	.....	2.70	2.60	2.75	21.....	2.60	2.80	2.90	.....
6.....	.....	2.70	2.15	2.70	22.....	2.85	2.90	2.80	.....
7.....	.....	2.60	2.60	2.70	23.....	2.70	2.70	2.75	.....
8.....	.....	2.30	2.70	2.50	24.....	2.60	3.00	2.50	.....
9.....	.....	2.15	2.75	2.45	25.....	2.30	2.75	2.70	.....
10.....	.....	2.55	2.75	(a)	26.....	2.55	2.90	2.40	.....
11.....	.....	2.80	2.65	.....	27.....	2.90	2.80	2.50	.....
12.....	.....	2.60	2.10	.....	28.....	2.50	2.70	3.20	.....
13.....	.....	2.65	2.15	.....	29.....	2.40	2.50	2.90	.....
14.....	.....	2.80	2.65	.....	30.....	2.80	2.40	2.70	.....
15.....	4.35	2.60	2.60	.....	31.....	.....	2.45	.....	.....
16.....	4.40	2.40	2.70	.....					

a River frozen over December 10–31.

WARE RIVER AT GILBERTVILLE, MASS.

Records of flow of Ware River have been kept at the lower mill through the courtesy and assistance of the George H. Gilbert Manufacturing Company, at Gilbertville, since September 22, 1904. The drainage area at this point is 160 square miles. The lower dam is 101.5 feet long with a fairly even crest. The greater part of the time, however, all of the water at this point is used through the wheels, and the record is kept largely by means of the record of wheel openings. These wheels have been rated at Holyoke, and, in addition to this, current-meter gagings are made from time to time as a check on the flow. The average head on wheels is about 19.5 feet. Records of flow at this point during 1904 are withheld, awaiting confirmation of data.

Observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

QUABOG RIVER AT WEST WARREN, MASS.

Quabog River is some 25 miles in length with a drainage area of 213 square miles. It is an especially valuable stream as regards water power, on account of its well sustained flow and absence of effect from freshets. There is still a large amount of power below West Warren which is not developed.

A station for securing a record of flow of Quabog River has been maintained by the United States Geological Survey at West Warren at the dam of J. T. F. MacDonnell, of Holyoke, since October 22, 1904. The drainage area at this point is 144 square miles. The dam is timber crib, 102.7 feet long between vertical abutments, and affords a fall of about 13 feet. This dam is leased by the Composite Leather Company, but no power is used at the present time; so that the whole flow is over the dam.

A plain staff gage is placed near the canal head-gates at the dam, on the left side. Elevation 50 of this gage corresponds to the level of the crest of the dam. This gage is read once a day by Amory Cressman. Records of flow at this point during 1904 have been withheld, awaiting confirmation of data.

Observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

SWIFT RIVER AT WEST WARE, MASS.

Swift River is some 30 miles long and drains a total area of 218 square miles. It drains a hilly country very similar to that of Ware River, but perhaps more thickly wooded. There is enough storage on this river to make the flow well sustained during the dry period.

Records of flow of Swift River have been kept at the mill of the West Ware Paper Company, through the courtesy of Mr. Dwight Holland, manager, since October 21, 1904. The drainage area at this point is 188 square miles. The dam at West Ware is timber crib; has a total length of 150 feet between vertical abutments, with a fairly good crest. A considerable portion of the time all of the water is used at this point through the wheels, and record is kept largely by means of them. One of the wheels has been rated at Holyoke, and additional current-meter measurements are made to serve as a check on the computations. The average head on the wheels is about 11 feet. Records of flow at this point during 1904 are withheld awaiting confirmation of data.

Observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

WESTFIELD RIVER AT RUSSELL, MASS.

The main branch of Westfield River rises in the northeasterly part of Berkshire County, entering Connecticut River at Springfield, with a total length of about 55 miles. Its principal tributaries are the West Branch and Middle Branch, respectively; length of the West Branch from the mouth being 22 miles and that of the Middle Branch 24 miles. The country in this drainage basin is very hilly and even mountainous at its headwaters. Slopes are steep and rocky. There is little storage, consequently rapid fluctuations in the flow.

This station was established April 1, 1904, by N. C. Grover. It is located at the steel highway bridge of two spans, which are about 250 feet long, near the railway station at Russell, Mass. The drainage area at this point is 331 square miles. A standard chain gage is attached to the upstream side of the bridge near the center of the left span; length of chain, 23.98 feet. The gage is referred to bench marks as follows: (1) Top of plank floor near the zero of gage scale; elevation, 22.89 feet. (2) Upstream inner corner of left abutment near post; elevation, 22.31 feet. (3) Upstream inner corner of right abutment near post; elevation, 24.76 feet. All elevations are referred to gage datum.

Discharge measurements are made from the bridge to which the gage is attached. The initial point for soundings is the face of left abutment, downstream side at the top. The channel is straight for 1,000 feet above and below the station. The bed of the stream is of gravel and small bowlders, very rough but permanent. Both banks are high, rocky, and clean, and not subject to overflow. There are two channels at all stages; current is swift at all times. The gage is read twice daily by B. A. Silliman, station agent at Russell.

Observations at this station during 1904 have been made under the direction of H. K. Barrows, district hydrographer.

Discharge measurements of Westfield River at Russell, Mass., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Square feet.	*Ft. per sec.*	*Feet.*	*Second-feet.*
April 2	N. C. Grover and S. K. Clapp.	700	7.13	3.37	4,990
April 27	S. K. Clapp	323	4.13	1.72	1,330
June 3	do	210	2.53	1.10	531
June 22	do	165	2.14	.98	353
July 29[a]	do	130	2.88	.85	374
July 30	do	132	1.59	.90	210
August 18	do	134	1.67	.90	224
September 16	H. K. Barrows and T. W. Norcross.	348	2.96	1.95	1,030
October 4	T. W. Norcross	167	1.49	.99	249
October 26	do	226	2.39	1.30	540
November 29[b]	do	161	1.21	.99	196

[a] Wading 1¼ miles below bridge. [b] Poor conditions due to anchor ice.

Mean daily gage height, in feet, of Westfield River at Russell, Mass., for 1904.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.80	2.15	1.10	2.20	0.80	0.90	1.30	1.10	1.1
2	3.65	1.90	1.10	1.75	.90	.90	1.10	1.05	1.1
3	2.75	1.80	1.10	1.40	.85	.85	1.00	1.05	1.1
4	2.20	1.70	1.05	1.20	.80	.80	.95	1.10	1.1
5	2.20	1.60	1.20	1.10	.80	.80	.90	1.10	1.1
6	2.45	1.55	1.60	1.40	.80	.80	.90	1.10	1.0
7	2.65	1.50	3.60	1.15	.70	.70	.90	1.05	.....
8	2.70	1.40	2.15	1.00	.70	.80	.85	1.00	.....
9	3.20	1.50	4.15	.95	.80	.80	.80	1.00	.....
10	3.30	1.70	2.45	.90	.80	.80	.85	1.00	.....
11	2.65	1.60	1.90	.95	2.55	.85	.90	1.00	.....
12	2.40	1.45	1.65	.95	1.40	.80	1.00	1.00	.....
13	2.20	1.30	1.45	1.05	1.10	.80	1.15	.95	.....
14	1.95	1.25	1.35	1.05	1.00	.80	1.20	1.00	.....
15	1.80	1.20	1.30	.95	1.10	4.20	1.10	1.05	.....
16	1.80	1.90	1.20	.90	1.00	2.00	1.00	1.10	.....
17	1.75	1.65	1.15	.90	.90	1.40	.95	1.05	.....
18	1.90	1.50	1.10	1.20	.90	1.20	.90	.95	.....
19	2.00	1.85	1.05	1.05	.85	1.10	.90	1.00	.....
20	1.80	2.30	1.05	.90	1.20	1.05	.90	1.10	.....
21	1.70	1.75	1.00	.90	2.00	1.00	3.40	1.25	.....
22	1.65	1.45	1.00	.70	1.30	1.00	2.45	1.30	.....
23	1.65	1.35	1.00	.80	1.10	.95	1.70	1.20	.....
24	1.65	1.30	1.00	.90	1.00	1.00	1.40	1.20	.....
25	1.80	1.20	.95	1.00	.95	1.00	1.30	1.15	.....
26	1.80	1.70	1.00	1.00	.90	1.05	1.20	1.05	.....
27	1.85	1.50	.95	1.00	.90	1.00	1.20	.95	.....
28	3.30	1.30	.95	1.00	.80	1.00	1.20	1.00	.....
29	3.50	1.20	1.00	.95	.80	1.00	1.15	1.00	.....
30	2.55	1.15	1.35	.90	.80	1.55	1.10	1.10	.....
31	.....	1.15	.....	.80	.80	.....	1.10	.....	.....

HOUSATONIC DRAINAGE BASIN.

Housatonic River has its source in Berkshire County, Mass. It flows southerly across Massachusetts and the western end of Connecticut, entering Long Island Sound. Its course is nearly parallel to the eastern boundary of New York State, and it receives the drainage from Tenmile River in New York.

Tenmile River drains an area of diversified topography, including broad flats and marshes in the basin of Swamp River and extensive areas under cultivation and sparsely timbered hills in the region of the Chestnut Range. The drainage area lies chiefly in New York State, the stream crossing the line into Connecticut one-half mile above the junction with the Housatonic. Stations have been maintained in this basin on Housatonic River at Gaylordsville, Conn., and on Tenmile River near Dover Plains, N. Y.

HOUSATONIC RIVER AT GAYLORDSVILLE, CONN.

This station was established October 24, 1900, by E. G. Paul. The gage is located at the covered wooden highway bridge at Gaylordsville, Conn., 2 miles below the mouth of Tenmile River and 1¼ miles above the cable from which discharge measurements are made. The chain gage is fastened to the woodwork of the inside of the bridge. The length of the chain from the end of the weight to the marker is 30.45 feet. The gage is read twice each day by G. H. Munroe. On account of the poor cross section of the channel at the bridge, discharge measurements are made by means of a three-fourths-inch cable and car 1¼ miles below. The cable has a span of 200 feet. It is supported on the right bank by timbers 25 feet high, and is anchored to a large rock buried in the ground. On the left bank the cable is supported by a large sycamore tree and fastened to the base of a large oak. The initial point for soundings is the zero of the tagged wire at the sycamore tree which supports the cable on the left bank. The channel is straight for about 500 feet above and below the station. The current at the cable never becomes too sluggish to be accurately measured. At high water the current is swift and rough. Both banks are subject to overflow only at extreme freshets. Both banks have a sparse growth of trees and brush. The bed of the stream is composed of gravel and cobblestones, free from vegetation, and not subject to change. No bench mark has been established. The center of the gage pulley is 29.35 feet above gage datum.

The observations at this station during 1904 have been made under the direction of R. E. Horton, district hydrographer.

Discharge measurements of Housatonic River at Gaylordsville, Conn., in 1900–1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
1900.		*Square feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
August 9 [a]	E. G. Paul	272	1.66	3.30	450
August 10 [a]	do	232	1.82	3.25	422
October 20	do	236	1.28	3.10	370
October 24	do	251	1.47	3.00	303
1901.					
March 30	A. K. Chittenden	1,014	4.64	6.20	4,718
April 27	do	1,311	5.65	7.20	7,419
August 3	A. E. Place	322	1.78	3.50	549
September 13	do	462	1.98	4.00	912
September 28	W. W. Schlecht	384	1.83	3.77	701
October 29	do	444	2.14	4.05	951
November 13	do	648	2.88	4.82	1,864
November 23	do	455	2.12	4.11	965
December 28	do	758	3.32	5.16	2,520
1902.					
January 11	W. W. Schlecht	677	3.23	5.00	2,184
February 14 [b]	do	446	2.49	8.30	1,111
March 4	do	2,090	6.51	9.90	13,600
March 18	do	1,469	5.64	7.63	8,259
May 3	do	1,010	4.41	6.10	4,459
June 23	do	498	2.36	4.46	1,177
July 11	H. K. Barrows	496	2.34	4.30	1,159
July 22	do	1,194	4.28	6.68	5,119
August 5	do	476	2.06	4.28	983
August 20	do	423	1.97	3.95	835
September 8	do	352	1.54	3.45	543
September 19	do	367	1.74	3.75	640
October 3	P. M. Churchill	693	3.08	5.35	2,133
November 15	F. H. Tillinghast	570	2.38	4.50	1,356
November 29	do	560	2.29	4.40	1,282
December 20	do	1,140	4.79	6.65	5,465
1903.					
January 23	F. H. Tillinghast	812	3.23	5.50	2,621
March 31	do	1,092	4.37	6.52	4,773
June 6	do	359	1.48	3.60	532
July 24	do	693	2.97	5.20	2,062
September 15	do	785	1.86	3.90	785
1904.					
July 16	C. C. Covert	363	1.64	3.80	596

[a] Measurement at different sections.

[b] Backwater from ice.

Mean daily gage height, in feet, of Housatonic River at Gaylordsville, Conn., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.85	6.85	6.25	6.15	6.00	4.85	5.40	3.80	3.55	4.45	4.25	4.25
2	4.75	6.15	6.05	6.75	5.90	4.75	5.85	3.80	3.60	4.50	4.40	4.25
3	4.05	6.60	6.30	6.60	5.60	4.65	5.20	3.85	3.55	4.30	4.45	4.15
4	4.10	6.65	7.65	6.70	5.55	4.60	4.65	4.00	3.60	4.00	4.50	4.05
5	4.10	6.40	6.10	6.45	5.25	4.55	4.35	4.00	3.60	4.20	4.45	4.00
6	4.05	6.45	5.45	6.10	5.20	4.45	4.40	3.85	3.15	4.25	4.45	3.85
7	[a] 4.10	6.30	[b] 6.00	6.10	5.05	4.20	4.55	3.85	3.40	4.20	4.30	4.00
8	3.95	8.45	9.15	6.00	5.10	5.30	4.60	3.70	3.35	4.10	4.20	4.05
9	4.10	8.00	7.35	6.15	4.65	6.55	4.50	3.40	3.45	4.15	4.25	3.95
10	4.55	8.40	6.65	6.50	4.50	7.35	4.45	3.85	3.70	4.05	4.20	3.90
11	4.65	8.50	6.75	6.45	4.55	7.05	4.30	3.90	3.70	3.75	4.25	3.85
12	4.55	6.90	6.00	6.40	4.60	6.60	3.85	5.30	3.60	4.15	4.15	4.05
13	5.50	6.30	5.60	6.30	4.50	6.15	4.30	4.85	3.35	4.25	4.20	4.00
14	5.85	7.10	5.45	6.15	4.70	5.55	4.25	3.90	3.35	4.25	4.45	3.90
15	6.15	6.90	5.30	5.85	4.70	5.10	4.15	3.90	7.35	4.00	4.45	3.95
16	6.20	6.10	5.05	5.90	5.25	5.05	4.15	4.20	6.60	4.15	4.55	4.15
17	[c] 6.35	6.10	5.00	5.55	5.00	4.85	4.00	4.10	6.00	4.20	4.45	4.20
18	5.95	6.25	4.95	5.60	5.25	4.75	4.00	4.00	5.00	4.05	4.30	[d] 4.15
19	5.85	6.10	5.05	5.50	5.25	4.70	4.05	3.80	4.65	4.05	4.30	4.10
20	6.25	[e] 5.90	5.30	5.45	5.15	4.60	3.55	4.05	4.55	4.20	4.25	4.05
21	6.40	6.50	5.30	5.50	5.15	4.25	3.90	4.40	4.55	5.10	4.30	4.20
22	6.60	7.10	5.65	5.40	5.15	4.65	4.00	4.50	4.15	6.10	4.35	4.25
23	7.80	8.50	5.65	5.30	4.95	4.50	3.70	4.25	4.00	5.85	4.60	4.05
24	9.25	8.00	6.35	5.15	4.70	4.30	3.50	4.20	3.95	5.05	4.55	4.20
25	9.25	[f] 8.00	6.50	5.05	4.90	4.00	3.75	4.10	4.45	5.40	4.30	4.30
26	[g] 8.55	7.00	6.80	5.10	4.75	4.25	3.70	3.80	4.30	5.25	4.50	4.30
27	9.15	4.00	7.55	5.20	5.75	4.15	4.55	3.80	4.25	4.85	4.20	4.25
28	8.00	[e] 5.00	7.50	6.15	5.30	3.75	4.10	3.80	4.40	4.80	4.05	4.70
29	8.05	4.20	7.05	6.40	5.10	4.15	3.95	3.35	4.30	4.70	4.10	4.50
30	7.85	.....	6.60	6.60	4.75	4.50	3.80	3.45	4.65	4.60	4.25	4.30
31	7.55	.....	6.10	.....	4.90	.....	3.80	3.50	.....	4.50	.....	[d] 4.20

[a] Ice 1 foot thick.
[b] Ice went out.
[c] Ice 1½ feet thick.
[d] December 18–31 river partly frozen. Ice 10–12 inches at gage.
[e] Ice 2½ feet thick.
[f] Ice 3 feet thick.
[g] Ice 2 feet thick.

Rating table for Housatonic River at Gaylordsville, Conn., from October 23, 1900, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.5	120	4.6	1,506	6.7	5,448	8.8	10,980
2.6	157	4.7	1,642	6.8	5,692	8.9	11,250
2.7	193	4.8	1,778	6.9	5,936	9.0	11,530
2.8	230	4.9	1,914	7.0	6,180	9.1	11,800
2.9	266	5.0	2,050	7.1	6,440	9.2	12,080
3.0	303	5.1	2,216	7.2	6,700	9.3	12,350
3.1	352	5.2	2,382	7.3	6,960	9.4	12,630
3.2	402	5.3	2,548	7.4	7,220	9.5	12,900
3.3	451	5.4	2,714	7.5	7,480	9.6	13,180
3.4	501	5.5	2,880	7.6	7,744	9.7	13,460
3.5	550	5.6	3,076	7.7	8,008	9.8	13,740
3.6	618	5.7	3,272	7.8	8,272	9.9	14,020
3.7	686	5.8	3,468	7.9	8,536	10.0	14,300
3.8	754	5.9	3,664	8.0	8,800	10.1	14,600
3.9	822	6.0	3,860	8.1	9,070	10.2	14,900
4.0	890	6.1	4,080	8.2	9,340	10.3	15,200
4.1	986	6.2	4,300	8.3	9,610	10.4	15,500
4.2	1,082	6.3	4,520	8.4	9,880	10.5	15,800
4.3	1,178	6.4	4,740	8.5	10,150		
4.4	1,274	6.5	4,960	8.6	10,430		
4.5	1,370	6.6	5,204	8.7	10,700		

The above table is applicable only for open-channel conditions. It is based upon discharge measurement made during 1900–1904. It is fairly well defined between gage heights 3 feet and 5 feet. Above 5 feet the measurements are scattered.

Mean daily discharge, in feet, of Housatonic River at Gaylordsville, Conn., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	.....	4,190	3,860	1,850	2,710	754	584	1,320	1,130	1,130
2	.....	.....	.....	5,570	3,660	1,710	3,570	754	618	1,370	1,270	1,130
3	.....	.....	.....	5,200	3,080	1,570	2,380	788	584	1,180	1,320	1,030
4	.....	.....	.....	5,450	2,980	1,510	1,570	890	618	890	1,370	988
5	.....	.....	.....	4,850	2,460	1,440	1,230	890	618	1,080	1,320	890
6	.....	.....	.....	4,080	2,380	1,320	1,270	788	377	1,130	1,320	788
7	.....	.....	.....	4,080	2,130	1,080	1,440	788	501	1,080	1,180	890
8	.....	.....	11,940	3,860	2,220	2,550	1,510	686	476	986	1,080	938
9	.....	.....	7,090	4,190	1,570	5,080	1,370	501	525	1,030	1,130	856
10	.....	.....	5,330	4,960	1,370	7,090	1,320	788	686	938	1,080	822
11	.....	.....	5,570	4,850	1,440	6,310	1,180	822	686	720	1,130	788
12	.....	.....	3,860	4,740	1,510	5,200	790	2,550	618	1,080	1,030	938
13	.....	.....	3,080	4,520	1,370	4,190	1,180	1,850	476	1,130	1,080	890
14	.....	.....	2,800	4,190	1,640	2,980	1,130	822	476	1,130	1,320	822
15	.....	.....	2,550	3,570	1,640	2,220	1,030	822	7,090	890	1,320	856
16	.....	.....	2,130	3,660	2,460	2,130	1,030	1,080	5,200	1,030	1,440	.....
17	.....	.....	2,050	2,980	2,050	1,850	890	986	3,860	1,080	1,320	.....
18	.....	.....	1,980	3,080	2,460	1,710	890	890	2,050	938	1,180	.....
19	.....	.....	2,130	2,880	2,460	1,640	938	754	1,570	938	1,180	.....
20	.....	.....	2,550	2,800	2,300	1,510	584	938	1,440	1,080	1,130	.....
21	.....	.....	2,550	2,880	2,300	1,130	822	1,270	1,440	2,220	1,180	.....
22	.....	.....	3,170	2,710	2,300	1,570	890	1,370	1,030	4,080	1,230	.....
23	.....	.....	3,170	2,550	1,980	1,370	686	1,130	890	3,570	1,510	.....
24	.....	.....	4,630	2,300	1,640	1,180	550	1,080	856	2,130	1,440	.....
25	.....	.....	4,960	2,130	1,910	890	720	986	1,320	2,710	1,180	.....
26	.....	.....	5,690	2,220	1,710	1,130	686	754	1,180	2,460	1,370	.....
27	.....	.....	7,610	2,380	3,370	1,030	1,440	754	1,130	1,850	1,080	.....
28	.....	.....	7,480	4,190	2,550	720	986	754	1,270	1,780	938	.....
29	.....	.....	6,310	4,740	2,220	1,030	856	476	1,180	1,640	986	.....
30	.....	.....	5,200	5,200	1,710	1,370	754	525	1,570	1,510	1,130	.....
31	.....	.....	4,080	.....	1,910	.....	754	550	.....	1,370	.....	.....

Estimated monthly discharge of Housatonic River at Gaylordsville, Conn., for 1904.

[Drainage area, 1,020 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
March 8–31	11,940	1,980	4,496	4.41	3.94
April	5,570	2,130	3,833	3.76	4.20
May	3,860	1,370	2,214	2.17	2.50
June	7,090	720	2,212	2.17	2.42
July	3,570	550	1,199	1.18	1.36
August	2,550	476	929	0.911	1.05
September	7,090	377	1,364	1.34	1.50
October	4,080	720	1,493	1.46	1.68
November	1,510	938	1,212	1.19	1.33
December 1–15	1,130	788	914	.896	.500

INDEX.

Ammonoosuc River at— Page
  Bretton Woods, N. H.:
    description 128–129
    discharge 129
    discharge, monthly 131
    gage heights 130
    rating table 130
Androscoggin River at and near—
  Dixfield, Me.:
    description 78–79
    discharge 79
    gage heights 79
  Errol dam, New Hampshire:
    description 75–76
  Gorham, N. H.:
    description 76
  Rumford Falls, Me.:
    description 78
  Shelburne, N. H.:
    description 76
    discharge 77
    gage heights 77
Androscoggin River drainage basin:
  description 74–75
Aroostook River at—
  Fort Fairfield, Me.:
    description 23–24
    discharge 24
    discharge, monthly 26
    gage heights 24–25
    rating table 25
Ashuelot River at—
  Winchester, N. H.:
    description 138
    discharge 139
    gage heights 139
Baring, Me.
  St. Croix River near:
    description 27–28
    discharge 28
    discharge, monthly 30
    gage heights 29
    rating table 30
Blackstone River at—
  Woonsocket, R. I.:
    description 109–110
    discharge 110
    gage heights 110–111
Blackstone River drainage basin:
  description 109
Bretton Woods, N. H.
  Ammonoosuc River at:
    description 128–129
    discharge 129

Bretton Woods, N. H.—Continued. Page.
  Ammonoosuc River at—Continued.
    discharge, monthly 131
    gage heights 130
    rating table 130
Carrabassett River at—
  North Anson, Me.:
    description 67–68
    discharge 68
    discharge, monthly 70
    gage heights 69
    rating table 70
Center Conway, N. H.
  Saco River near:
    description 82
    discharge 82
    discharge, monthly 84
    gage heights 83
    rating table 84
Clinton, Mass.
  Nashua River (South Branch) at:
    description 108
    rainfall 108
    yield 108–109
Cobbosseecontee River at—
  Gardiner, Me.:
    description 73–74
    discharge 74
Cochituate, Mass.
  Lake Cochituate at:
    description 105
    rainfall 107
    yield 107
Cold Stream at—
  Enfield, Me.:
    description 50–51
    discharge 51
    gage heights 51
Connecticut River at and near—
  Hartford, Conn.:
    description 121–122
    gage heights 122
  Orford, N. H.:
    description 115
    discharge 116
    discharge, monthly 119
    gage heights 117
    rating table 118–119
  Sunderland, Mass.:
    description 120
    discharge 120
    gage heights 121
Connecticut River drainage basin:
  description 113–115

	Page.
Contoocook River at—	
West Hopkinton, N. H.:	
description	101–102
discharge	102
discharge, monthly	104
gage heights	103
rating table	104
Dead River near—	
The Forks, Me.:	
description	66
discharge	66
gage heights	67
Dedham, Me.:	
Phillips Lake in:	
description	52–53
gage heights	54
Deerfield, Mass.	
Deerfield River at:	
description	140
discharge	141
gage heights	141
Deerfield River at—	
Deerfield, Mass.:	
description	140
discharge	141
gage heights	141
Dixfield, Me.	
Androscoggin River near:	
description	78–79
discharge	79
gage heights	79
East Holden, Me.	
Phillips Lake near:	
description	52–53
gage heights	54
Phillips Lake (north outlet) at:	
description	52–53
discharge	53
East Pembroke, N. H.	
Suncook River at:	
description	105
Enfield, Me.	
Cold Stream at:	
description	50–51
discharge	51
gage heights	51
Errol dam, New Hampshire.	
Androscoggin River at:	
description	75–76
Fish River at—	
Wallagrass, Me.:	
description	21–22
discharge	22
gage heights	25
Fort Fairfield, Me.	
Aroostook River at:	
description	23–24
discharge	24
discharge, monthly	26
gage heights	24–25
rating table	25
Foxcroft, Me.	
Piscataquis River near:	
description	47–48
discharge	48
discharge, monthly	50
gage heights	48–49
rating table	49
Framingham, Mass.	Page.
Sudbury River at:	
description	105
run-off	106
Franklin Junction, N. H.	
Merrimac River at:	
description	86
discharge	87
discharge, monthly	88
gage heights	87
rating table	88
Gardiner, Me.	
Cobbosseecontee River at:	
description	73–74
discharge	74
Garvins Falls, New Hampshire.	
Merrimac River at:	
description	89
Gaylordsville, Conn.	
Housatonic River at:	
description	147
discharge	148
discharge, mean daily	151
discharge, monthly	152
gage heights	149
rating table	150
Gilbertville, Mass.	
Ware River at:	
description	143
Gorham, N. H.	
Androscoggin River at:	
description	76
Greenlake, Me.	
Phillips Lake (southeast outlet) near:	
description	52–53
discharge	54
Grindstone, Me.	
Penobscot River (East Branch) at:	
description	40–41
discharge	41
discharge, monthly	43
gage heights	42
rating table	43
Hartford, Conn.	
Connecticut River at:	
description	121–122
gage heights	122
Holden, Me.	
Phillips Lake in:	
description	52–53
Housatonic River at—	
Gaylordsville, Conn.:	
description	147
discharge	148
discharge, mean daily	151
discharge, monthly	152
gage heights	149
rating table	150
Housatonic River drainage basin:	
description	147
Israel River (above South Branch) near—	
Jefferson Highlands, N. H.:	
description	123
discharge	123
discharge, monthly	125
gage heights	124
rating table	124

Israel River (below South Branch) near— Page.
Jefferson Highlands, N. H.:
description 125–126
discharge 126
discharge, monthly 128
gage heights 127
rating table 127
Jefferson Highlands, N. H.
Israel River (above South Branch) near:
description 123
discharge 123
discharge, monthly 125
gage heights 124
rating table 124
Israel River (below South Branch) near:
description 125–126
discharge 126
discharge, monthly 128
gage heights 127
rating table 127
Kennebec River at—
North Anson, Me.:
description 59–60
discharge 60
discharge, monthly 62
gage heights 61
rating table 62
The Forks, Me.:
description 56–57
discharge 57
discharge, monthly 59
gage heights 58
rating table 58
Waterville, Me.:
description 62–63
discharge 63
Kennebec River drainage basin:
description 55–56
Lake Cochituate at—
Cochituate, Mass.:
description 105
rainfall 107
yield 107
Lawrence, Mass.
Merrimac River at:
description 89–90
flow 90–93
Little River near—
Twin Mountain, N. H.:
description 134–135
discharge 135
gage heights 135
Machias River near—
Whitneyville, Me.
description 31
discharge 32
discharge, monthly 33
gage heights 32
rating table 33
Machias River drainage basin:
description 31
Madison, Me.
Sandy River near:
description 71–72
Mattawamkeag, Me. Page.
Mattawamkeag River at:
description 44
discharge 45
discharge, monthly 47
gage heights 45–46
rating table 46
Mattawamkeag River at—
Mattawamkeag, Me.:
description 44
discharge 45
discharge, monthly 47
gage heights 45–46
rating table 46
Merrimac River at—
Franklin Junction, N. H.:
description 86
discharge 87
discharge, monthly 88
gage heights 87
rating table 88
Garvins Falls, New Hampshire:
description 89
Lawrence, Mass.:
description 89–90
flow 90–93
Merrimac River drainage basin:
description 85–86
Messalonskee River at—
Waterville, Me.:
description 72
discharge 73
Millinocket, Me.
Penobscot River at—
description 36
discharge 37
Moose River near—
Rockwood, Me.:
description 64
gage heights 64
Nashua River (South Branch) at—
Clinton, Mass.:
description 108
rainfall 108
yield 108–109
North Anson, Me.
Carrabassett River at:
description 67–68
discharge 68
discharge, monthly 70
gage heights 69
rating table 70
Kennebec River at:
description 59–60
discharge 60
discharge, monthly 62
gage heights 61
rating table 62
Orford, N. H.
Connecticut River near:
description 115
discharge 116
discharge, monthly 119
gage heights 117
rating table 118–119

	Page.
Pemigewasset River at—	
Plymouth, N. H.:	
description	93–94
discharge	94
discharge, monthly	97–101
gage heights	95
rating table	96
Penobscot River at—	
Millinocket, Me.:	
description	36
discharge	37
West Enfield, Me.:	
description	37–38
discharge	38
discharge, monthly	40
gage heights	39
rating table	40
Penobscot River (East Branch) at—	
Grindstone, Me.:	
description	40–41
discharge	41
discharge, monthly	43
gage heights	42
rating table	43
Penobscot River drainage basin:	
description	34–36
Phillips Lake in—	
Holden and Dedham, Me.:	
description	52–53
gage heights	54
Phillips Lake (north outlet) at—	
East Holden, Me.:	
description	52–53
discharge	53
gage heights	54
Phillips Lake (southeast outlet) near—	
Greenlake, Me.:	
description	52–53
discharge	54
Piscataquis River near—	
Foxcroft, Me.:	
description	47–48
discharge	48
discharge, monthly	50
gage heights	48–49
rating table	49
Plymouth, N. H.	
Pemigewasset River at:	
description	93–94
discharge	94
discharge, monthly	97–101
gage heights	95
rating table	96
Presumpscot River at—	
Sebago Lake, Maine:	
description	80–81
discharge	81
Presumpscot River drainage basin:	
description	80
Quabog River at—	
West Warren, Mass.:	
description	144
Roach River, Me.	
Roach River at:	
description	65
gage heights	65
Roach River at—	
Roach River, Me.:	
description	65
gage heights	65
Rockwood, Me.	
Moose River near:	
description	64
gage heights	64
Rumford Falls, Me.	
Androscoggin River at:	
description	78
Russell, Mass.	
Westfield River at:	
description	145
discharge	146
gage heights	146
Saco River near—	
Center Conway, N. H.:	
description	82
discharge	82
discharge, monthly	84
gage heights	83
rating table	84
Saco River drainage basin:	
description	81–82
St. Croix River near—	
Baring, Me.:	
description	27–28
discharge	28
discharge, monthly	30
gage heights	29
rating table	30
St. Croix River drainage basin:	
description	26–27
St. John River drainage basin:	
description	20–21
Sandy River near—	
Madison, Me.:	
description	71–72
Sebago Lake, Maine—	
Presumpscot River at outlet of:	
description	80–81
discharge	81
Sharon, Vt.	
White River at:	
description	136
discharge	136
discharge, monthly	138
gage heights	137
rating table	137
Shelburne, N. H.	
Androscoggin River at:	
description	76
discharge	77
gage heights	77
Shetucket River near—	
Willimantic, Conn.:	
description	112
discharge	112
gage heights	113
Sudbury River at—	
Framingham, Mass.:	
description	105
run-off	106
Suncook River at—	
East Pembroke, N. H.:	
description	105

Sunderland, Mass. Page.
Connecticut River at:
description 120
discharge 120
gage heights 121
Swift River at—
West Ware, Mass.:
description 144
Thames River drainage basin:
description 111
The Forks, Me.
Dead River near:
description 66
discharge 66
gage heights 67
Kennebec River at:
description 56–57
discharge 57
discharge, monthly 59
gage heights 58
rating table 58
Twin Mountain, N. H.
Little River near:
description 134–135
discharge 135
gage heights 135
Zealand River near:
description 131–132
discharge 132
discharge, monthly 134
gage heights 133
rating table 133
Wallagrass, Me.
Fish River at:
description 21–22
discharge 22
gage heights 23
Ware, Mass:
Ware River near:
description 142
discharge 143
gage heights 143
Ware River at and near—
Gilbertville, Mass.:
description 143
Ware, Mass.:
description 142
discharge 143
gage heights 143
Waterville, Me.
Kennebec River at:
description 62–63
discharge 63
Messalonskee River at:
description 72
discharge 73
West Enfield, Me.
Penobscot River at:
description 37–38
West Enfield, Me.—Continued. Page.
Penobscot River at—Continued.
discharge 38
discharge, monthly 40
gage heights 39
rating table 40
West Hopkinton, N. H.
Contoocook River at:
description 101–102
discharge 102
discharge, monthly 104
gage heights 103
rating table 104
West Ware, Mass.
Swift River at:
description 144
West Warren, Mass.
Quabog River at:
description 144
Westfield River at—
Russell, Mass.:
description 145
discharge 146
gage heights 146
White River at—
Sharon, Vt.:
description 136
discharge 136
discharge, monthly 138
gage heights 137
rating table 137
Whitneyville, Me.
Machias River near:
description 31
discharge 32
discharge, monthly 33
gage heights 32
rating table 33
Willimantic, Conn.
Shetucket River near:
description 112
discharge 112
gage heights 113
Winchester, N. H.
Ashuelot River at:
description 138
discharge 139
gage heights 139
Woonsocket, R. I.
Blackstone River at:
description 109–110
discharge 110
gage heights 110–111
Zealand River near—
Twin Mountain, N. H.:
description 131–132
discharge 132
discharge, monthly 134
gage heights 133
rating table 133

O

PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Water-Supply Paper No. 124.]

The publications of the United States Geological Survey consist of (1) Annual Reports; (2) Monographs; (3) Professional Papers; (4) Bulletins; (5) Mineral Resources; (6) Water-Supply and Irrigation Papers; (7) Topographic Atlas of United States, folios and separate sheets thereof; (8) Geologic Atlas of United States, folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

Most of the above publications may be obtained or consulted in the following ways:

1. A limited number are delivered to the Director of the Survey, from whom they map be obtained, free of charge (except classes 2, 7, and 8), on application.

2. Every member of Congress is allotted a certain number, from whom they may be obtained, free of charge, on application.

3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they may be had at practically cost.

4. Copies of all Government publications are furnished to the principal public libraries in the large cities throughout the United States, where they may be consulted by those interested.

The Professional Papers, Bulletins, and Water-Supply Papers treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous; H, Forestry; I, Irrigation; J, Water storage; K, Pumping water; L, Quality of water; M, General hydrographic investigations; N, Water power; O, Underground waters; P, Hydrographic progress reports.

Series P.—The hydrographic progress reports contain the results of stream measurements. A report is issued for every calendar year, containing the results of data collected during that year. These reports were first published as a part of the Director's annual report or as a bulletin; they are now published as water-supply and irrigation papers. The following is a list, by years, of the publications containing the progress reports of stream measurements. A detailed index of these reports is published as Water-Supply Paper No. 119.

1888. Tenth Annual Report, Part II.
1889. Eleventh Annual Report, Part II.
1890. Twelth Annual Report, Part II.
1891. Thirteenth Annual Report, Part III.
1892. Fourteenth Annual Report, Part II.
1893. Bulletin No. 131.
1894. Bulletin No. 131; Sixteenth Annual Report, Part II.
1895. Bulletin No. 140.
1896. Water-Supply Paper No. 11; Eighteenth Annual Report, Part IV,
1897. Water-Supply Papers Nos. 15 and 16; Nineteenth Annual Report, Part IV.
1898. Water-Supply Papers Nos. 27 and 28; Twentieth Annual Report, Part IV.
1899. Water-Supply Papers Nos. 35, 36, 37, 38, and 39; Twenty-first Annual Report, Part IV.
1900. Water-Supply Papers Nos. 47, 48, 49, 50, 51, and 52; Twenty-second Annual Report, Part IV.
1901. East of Mississippi River, Water-Supply Papers Nos. 65 and 75.
West of Mississippi River, Water-Supply Papers Nos. 66 and 75.
1902. East of Mississippi River, Water-Supply Papers Nos. 82 and 83.
West of Mississippi River, Water-Supply Papers Nos. 84 and 85.

1903. East of Mississippi River, Water-Supply Papers Nos. 97 and 98.
West of Mississippi River, Water-Supply Papers Nos. 99 and 100.
1904. East of Mississippi River, Water-Supply Papers Nos. 124, 125, 126, 127, 128, and 129.
West of Mississippi River, Water-Supply Papers Nos. 130, 131, 132, 133, 134, and 135.

The Geological Survey and the Reclamation Service have suboffices in different parts of the United States, from which hydrographic and reclamation work in the respective localities is carried on, and where data may be obtained on application. These offices are located as follows:

Boston, Mass., 6 Beacon street; Utica, N. Y., 75 Arcade; Atlanta, Ga., 409 Temple court; Austin, Tex., University of Texas; Chicago, Ill., Federal Building; Belle Fourche, S. Dak.; Cody, Wyo.; Denver, Colo., Chamber of Commerce Building; Salt Lake, Utah; Los Angeles, Cal., 1106 Braly Building; San Francisco, Cal., 422 Merchants' Exchange Building; Phoenix, Ariz.; Carlsbad, N. Mex.; El Paso, Tex.; Billings, Mont.; Great Falls, Mont.; Hazen, Nev.; Boise, Idaho; Spokane, Wash., 424 Peyton Block; Pendleton, Oreg.

Correspondence should be addressed to

THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, D. C.

LIBRARY CATALOGUE SLIPS.

[Mount each slip upon a separate card, placing the subject at the top of the second slip. The name of the series should not be repeated on the series card, but the additional numbers should be added, as received, to the first entry.]

Author.

U. S. Geological survey.

. . . Report of progress of stream measurements for the calendar year 1904. Prepared under the direction of F. H. Newell by H. K. Barrows and John C. Hoyt. Pt. I.—Atlantic Coast of New England drainage. Washington, Gov't print. off., 1905.

157, iii p. illus. II pl. (incl. map) 23cm. (U. S. Geological survey. Water-supply and irrigation paper no. 124.)

Subject series: P, Hydrographic progress reports, 29.

1. Stream measurements. 2. Rivers—U. S. I. Barrows, Harold K. II. Hoyt, John Clayton, 1871–.

Subject.

U. S. Geological survey.

. . . Report of progress of stream measurements for the calendar year 1904. Prepared under the direction of F. H. Newell by H. K. Barrows and John C. Hoyt. Pt. I.—Atlantic Coast of New England drainage. Washington, Gov't print. off., 1905.

157, iii p. illus. II pl. (incl. map) 23cm. (U. S. Geological survey. Water-supply and irrigation paper no. 124.)

Subject series: P, Hydrographic progress reports, 29.

1. Stream measurements. 2. Rivers—U. S. I. Barrows, Harold K. II. Hoyt, John Clayton, 1871–.

Series.

U. S. Geological survey.

Water-supply and irrigation papers.

no. 124. Report of progress of stream measurements for . . . 1904 . . . by H. K. Barrows and J. C. Hoyt. Pt. I. 1905.

References.

U. S. Dept. of the Interior.

see also

U. S. Geological survey.

Water-Supply and Irrigation Paper No. 125 Series P, Hydrographic Progress Reports, 30

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

REPORT

OF

PROGRESS OF STREAM MEASUREMENTS

FOR

THE CALENDAR YEAR 1904

PREPARED UNDER THE DIRECTION OF F. H. NEWELL
BY
R. E. HORTON, N. C. GROVER, and JOHN C. HOYT

PART II.—Hudson, Passaic, Raritan, and Delaware River Drainages

WASHINGTON
GOVERNMENT PRINTING OFFICE
1905

CONTENTS.

	Page.
Letter of transmittal	7
Introduction	9
Cooperation and acknowledgments	18
Hudson River drainage basin	19
Hudson River at Fort Edward, N. Y	19
Hudson River at Mechanicsville, N. Y	22
Indian River at Indian Lake, Hamilton County, N. Y	24
Hoosic River at Buskirk, N. Y	24
Mohawk River at Little Falls, N. Y	26
Mohawk River at Dunsbach Ferry Bridge, N. Y	29
Oriskany Creek near Oriskany, N. Y	32
Starch Factory Creek near New Hartford, N. Y	35
Sylvan Glen Creek near New Hartford, N. Y	37
Graefenberg Creek near New Hartford, N. Y	39
Reels Creek and Johnston Brook near Deerfield, N. Y	41
Nail Creek at Utica, N. Y	45
West Canada Creek at Twin Rock Bridge, N. Y	46
East Canada Creek at Dolgeville, N. Y	50
Schoharie Creek at Prattsville, N. Y	54
Batavia Kill near Prattsville, N. Y	59
Catskill Creek at South Cairo, N. Y	60
Esopus Creek near Olivebridge, N. Y	63
Esopus Creek at Kingston, N. Y	66
Wappinger Creek near Wappinger Falls, N. Y	70
Croton River at old Croton dam, New York	71
Miscellaneous measurements	73
Passaic River drainage basin	73
Passaic River at Millington, N. J	74
Passaic River near Chatham, N. J	76
Pompton River at Pompton Plains, N. J	78
Ramapo River near Mahwah, N. J	79
Wanaque River at Wanaque, N. J	82
Rockaway River near Boonton, N. J	84
Raritan River drainage basin	84
Raritan River (South Branch) at Stanton, N. J	85
Raritan River at Finderne, N. J	87
Raritan River at Boundbrook, N. J	90
Raritan River (North Branch) near Pluckemin, N. J	91
Millstone River at Millstone, N. J	93
Delaware River drainage basin	94
Delaware River (West Branch) at Hancock, N. Y	96
Delaware River (East Branch) at Hancock, N. Y	98
Delaware River at Lambertville, N. J	99
Lehigh River near South Bethlehem, Pa	101
Musconetcong River near Bloomsbury, N. J	102
Tohickon Creek at Point Pleasant, Pa	104
Neshaminy Creek at forks, Pennsylvania	105
Schuylkill River near Philadelphia, Pa	107
Perkiomen Creek at Frederick, Pa	108
Index	111

ILLUSTRATIONS.

		Page.
PLATE	I. Map showing location of principal gaging stations in the United States	10
	II. Price current meters, with buzzers	12
FIG.	1. Cable station, showing section of the river, car, gage, etc	11

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
HYDROGRAPHIC BRANCH,
Washington, D. C., May 4, 1905.

SIR: I transmit herewith the manuscript of Part II of a series of twelve papers which compose the Report of Progress of Stream Measurements for the Calendar Year 1904. Parts I to VI of this report contain the results of the data collected in the territory east of Mississippi River. Parts VII to XII are devoted to the data collected in the territory west of Mississippi River.

The larger part of the original data for this report was collected under the direction of district hydrographers R. E. Horton and N. C. Grover. Mr. Horton had charge of the work in New York, and was assisted by C. C. Covert and H. R. Beebe. The computations for that portion of the report were made under the direction of Mr. Horton. Mr. Grover had charge of the work in New Jersey, and was assisted by F. H. Tillinghast and Frank H. Brundage. A limited amount of the data was collected by other parties, as shown in the list of acknowledgments. The assembling of the data and its preparation for publication were done under the direction of J. C. Hoyt, who has been assisted by R. H. Bolster, Robert Follansbee, W. E. Hall, F. H. Tillinghast, H. D. Padgett, and A. H. Horton.

I request that this manuscript be published as one of the series of Water-Supply and Irrigation Papers.

Very respectfully,

F. H. NEWELL,
Chief Engineer.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

PROGRESS REPORT OF STREAM MEASUREMENTS FOR THE CALENDAR YEAR 1904.

PART II.

By R. E. Horton, N. C. Grover, and J. C. Hoyt.

INTRODUCTION.

The hydrographic work of the United States Geological Survey includes the collection of facts concerning and the study of conditions affecting the behavior of water from the time it reaches the earth as rain or snow until it joins the oceans or great navigable rivers. These investigations became a distinct feature of the work of the Survey in the fall of 1888, when an instruction camp was established at Embudo, N. Mex. Since that date the work has been continually and gradually extended as larger funds became available. The first distinctive appropriation for gaging streams was made by the act of August 18, 1894, which contained an item of $12,500, "for gaging the streams and determining the water supply of the United States, including the investigation of underground currents and artesian wells in the arid and semiarid sections." (Digest of Appropriations for 1895, p. 270.)

Since that time a similar act has been passed each year and the appropriations have gradually increased, as shown in the following table:

Annual appropriations for hydrographic surveys.

Year ending June 30, 1895	$12,500
Year ending June 30, 1896	25,000
Year ending June 30, 1897	50,000
Year ending June 30, 1898	50,000
Year ending June 30, 1899	50,000
Year ending June 30, 1900	50,000
Year ending June 30, 1901	100,000
Year ending June 30, 1902	100,000
Year ending June 30, 1903	200,000
Year ending June 30, 1904	200,000
Year ending June 30, 1905	200,000
Year ending June 30, 1906	200,000

The chief feature of the work of the hydrographic division is the systematic study of the flow of the surface waters and the conditions affecting the same. In this connection other information that may be of use to the engineer or others in hydrographic studies, such as river profiles, duration and extent of damage by floods, water-power data, etc., is collected. Furthermore, the work has been so directed that the information collected will be of direct value in the commercial and agricultural development of the country.

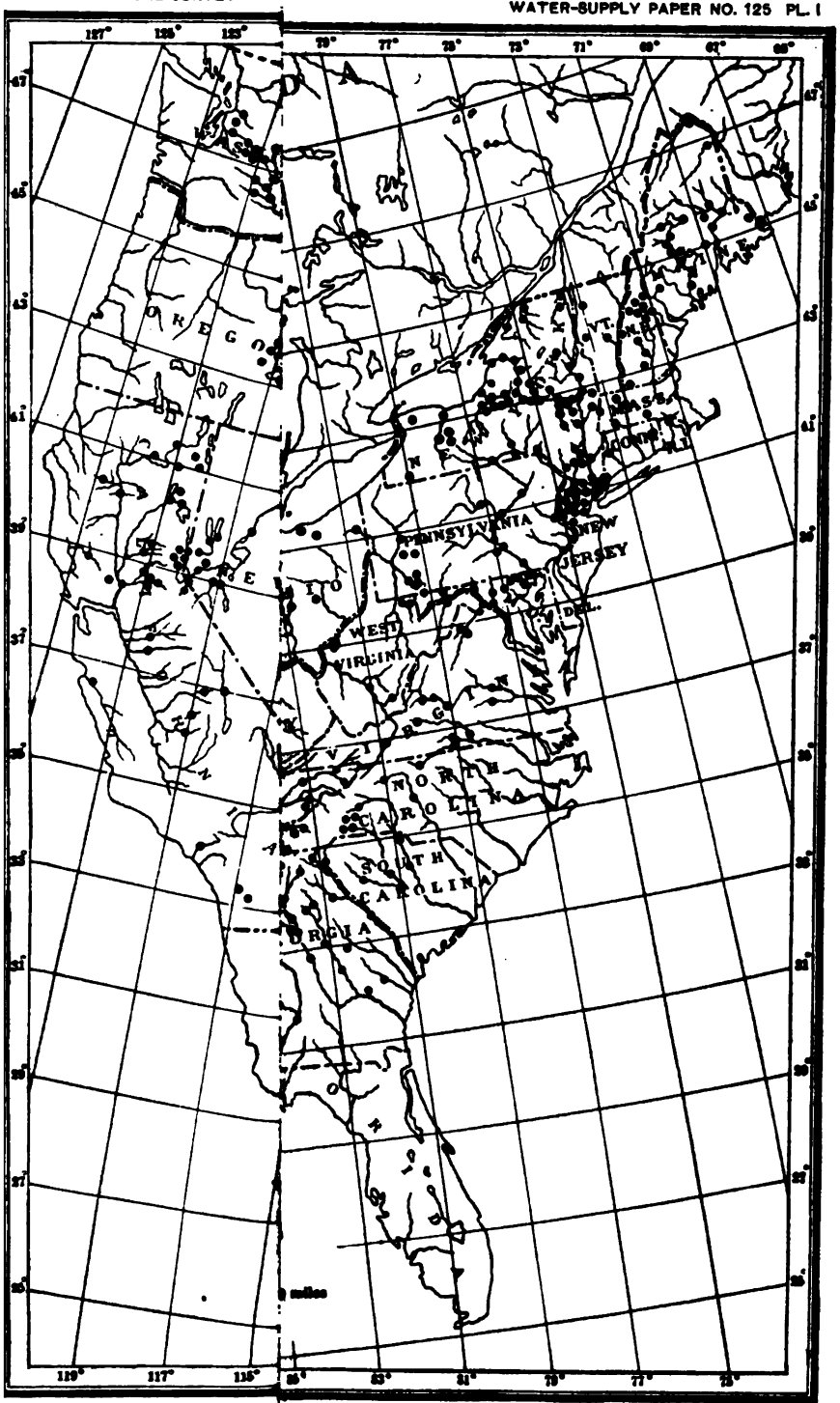
As a result of the increased appropriations since June 30, 1902, the work has been largely extended and thoroughly systemized. The various States have been grouped into districts, each of which is under the supervision of a district hydrographer who, with a corps of assistants, devotes his whole time to the study of the hydrographic resources of his district.

The methods used in the collection of these data and in their preparation for publication are given in detail in Water-Supply Paper No. 94. (Hydrographic Manual, U. S. Geol. Survey.)

The general plan of stream gaging which has been developed is to obtain eventually data in regard to the flow of all the important streams in the United States. With this in view gaging stations are established at points where the data will be of greatest commercial value. At these stations discharge measurements are taken from time to time as typical river stages, and the daily surface fluctuation is obtained by means of gage readings. From these two factors it is possible to estimate both the total flow and its distribution through the period of observation.

The selection of the site for a gaging station and the length of time the station is maintained depend largely upon the needs of each locality. If the stream is to be used for water power, special efforts are made to obtain information concerning the low-water flow. If water is to be stored, the high waters are given special attention. In all sections certain permanent stations are maintained for general statistical purposes to show the conditions which exist through long periods. They also act as primary stations, and are used in connection with short series of measurements to determine the flow in particular portions of the drainage basin.

Gaging stations are divided into two general classes: First, current-meter stations, and, second, weir stations. The former class is subdivided as to location into bridge, cable, boat, and wading stations. Fig. 1 shows a cable station with car, tag line, inclined gage, etc. In addition to the bridge, cable, or boat, the equipment of a current-meter gaging station consists in a gage for determining the daily fluctuations of the water surface, bench marks to which the zero of the gage is referred, and permanent marks on the bridge or a tagged line indicating the points of measurement. Where the current is



MAINED DURING 1904.

swift some appliance, generally a secondary cable, is necessary to hold the meter below the surface.

Gaging stations are generally located at bridges, if the channel conditions are satisfactory, as from them the meter can be easily manipulated, and the cost of the equipment is comparatively small. The stations are located as far as possible at points where the channel is straight, both above and below the gaging section, and where there are no cross currents, backwater, or boils. The bed of the stream should be as clear as possible from large projections and of a permanent character. The banks should be high, and should overflow at high stages only. At stations with shifting beds more measurements are made, and special methods of computing daily discharges are employed. Great care is taken in the selection and equipment of gaging stations in order that the data may have the required degree of accuracy.

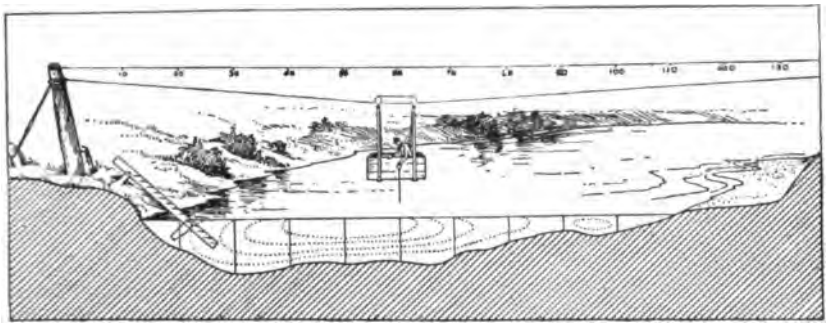


FIG. 1.—Cable station, showing section of river, car, gage, etc.

On many of the larger rivers, where water power is developed by dams, estimates of flow are obtained by observing the head on the crest and using a weir formula. On the smaller streams sharp-crested weirs are in some cases erected.

The principal instrument used in stream-measurement work is the current meter, by which the velocity of the flow of water is determined. After years of experience the Survey has adopted the Price current meter for general work. This meter, as is shown on Pl. II, is made in two sizes, known as the large and small Price. The small Price has been largely developed by the officers of the Survey, using the Price acoustic meter as a basis.

A discharge measurement is the determination of the quantity of water flowing past a certain point at a given time. This quantity is the product of two factors: (1) The mean velocity, which is the function of the cross section, surface slope, wetted perimeter, and roughness of bed; (2) the area, which depends upon the permanency of the bed and the fluctuations of the surface, which govern the depth.

In making the measurement an arbitrary number of points are laid off perpendicular to the thread of the stream (see fig. 1). These points are usually at regular intervals varying from 2 to 20 feet, depending upon the size and conditions of the stream. They are known as measuring points, and at them the observed data, the velocities and soundings, are taken. The perpendiculars dropped from the measuring points divide the gaging section into strips, and for each strip or pair of strips the mean velocity, area, and discharge are determined independently; thus conditions existing in one part of the stream are not distributed to parts where they do not apply.

The methods of obtaining velocity with the current meters which are in general use may be grouped into three classes: Single point, multiple point, and integration.

The single-point method consists in holding the meter either at the depth of the thread of mean velocity, or at an arbitrary depth for which the coefficient for reducing to mean velocity has been determined. Extensive experiments by vertical velocity-curves show that the thread of mean velocity lies at from 0.5 to 0.7 of the total depth. In general practice the thread of mean velocity is considered to be at 0.6 depth, and it is at this depth that the meter is held in the majority of the measurements, this being known as the six-tenth depth method. It is found by a large number of vertical velocity-curve measurements, taken on various streams and under various conditions, that the coefficient for reducing the velocity obtained at six-tenths depth to mean velocity is practically unity, ranging, in a series of 910 measurements made at 39 gaging stations, between 0.94 and 1.04, with a mean for the 910 observations of 1.00. In the other principal single-point method the meter is held near the surface, usually 1 foot below, or low enough to be out of the action of the wind or other disturbing influences. This is known as the subsurface method. The coefficient for reducing the velocities taken at the subsurface has been found by repeated experiments with vertical velocity-curves to be from 0.85 to 0.95, depending upon the depth of the stream and velocity and channel conditions. This method is specially adapted for flood measurements, or when the velocity is so great that the meter can not be kept at 0.6 depth.

The three principal multiple-point methods in general use are: The vertical velocity-curve; top and bottom; and top, bottom, and mid depth. In the vertical velocity-curve method a series of velocity determinations are taken in the vertical at regular intervals, usually from 0.5 to 1 foot apart. By plotting these velocities as abscissas and their depths as ordinates, and drawing a smooth curve through these points, the vertical velocity-curve is produced, which shows the change in velocity from the surface to the bottom of the stream. The mean velocity in the vertical is then obtained by dividing the depth

PRICE CURRENT METERS, WITH BUZZERS.

into the area bounded by this mean velocity curve and the initial line. Owing to the length of time it takes to make these measurements they are seldom used except for determining coefficients for purposes of comparison and for measurements under ice.

In the second multiple-point method the meter is held from 0.5 to 1 foot below the surface and about 0.5 foot above the bottom, and the mean of the velocities at these two points is taken as the mean velocity for that vertical. This method is not well adapted for general work, as the roughness of the bottom disturbs the velocity at that point. For shallow streams with comparatively smooth beds good results are obtained by this method. In the third multiple-point method the meter is held at mid depth, 0.5 foot below the surface and 0.5 foot above the bottom, and the mean velocity is determined by dividing the sum of the top velocity, twice the mid-depth velocity, and the bottom velocity by 4.

The vertical integration method consists in moving the meter at a slow, uniform speed from the surface to the bottom and back again to the surface. The number of revolutions and the time taken in the operation is noted, and the mean velocity is found by dividing the number of revolutions by the number of seconds taken in the run. This method has the advantage in that the velocity at each point of the vertical is measured twice. It is well adapted for measurements under ice and as a check on the point methods.

The area, which is the other factor for determining the discharge of the stream, depends upon the stage of the river, which is taken on a gage, and the general contour of the bed of the stream, which is found by sounding. The soundings are usually taken at each measuring point at the time of the discharge measurement, either by using the meter and cable or by a special sounding line or rod. For stations with permanent beds standard cross sections are usually taken during low water. These sections serve to check the soundings which are taken at the time of the measurements, and from them any change which may have taken place in the bed of the stream can be detected. They are also used for obtaining the area for use in high-water measurement computations, as accurate soundings are hard to obtain at high stages.

In computing the discharge measurements from the observed velocities and depths at the various points of measurements the measuring section is divided into elementary strips, as shown in fig. 1, and the mean velocity, area, and discharge are determined separately for either a single or double strip. The total discharge and area are the sums of those for the various strips, and the mean velocity is obtained by dividing the total discharge by the total area.

The volume of water flowing in a stream is known as run-off. In expressing it various units are used, depending upon the kind of work for which the data are needed. Those used in this report are "second-

feet," "acre-feet," "run-off per square mile," and "run-off in depth in inches," and may be defined as follows:

"Second-foot" is an abbreviation for cubic foot per second, and is the body of water flowing in a stream 1 foot wide, 1 foot deep, at a rate of 1 foot per second.

The "acre-foot" is the unit of capacity used in connection with storage for irrigation work, and is equivalent to 43,560 cubic feet. It is the quantity required to cover an acre to a depth of 1 foot. There is a convenient relation between the second-foot and the acre-foot; 1 second-foot flowing for twenty-four hours will deliver 86,400 cubic feet, which equals 1.9835 acre-feet, or, approximately, 2 acre-feet.

The expression "second-feet per square mile" means the average number of cubic feet of water flowing each second from every square mile of drainage area on the assumption that the run-off is uniformly distributed.

"Depth in inches" means the depth of water in inches that would have covered the drainage area, uniformly distributed, if all the water could have accumulated on the surface. This quantity is used for comparing run-off with rainfall, which quantity is usually given in depth in inches.

It should be noticed that "acre-feet" and "depth in inches" represent the actual quantities of water which are produced during the periods in question, while "second-feet," on the contrary, is merely a rate of flow per second.

The base data for computing the daily discharge of a stream are the daily gage heights and the various discharge measurements, of which there should be a sufficient number to cover the range of stage. The fundamental laws upon which these computations are based are the following:

(1) The discharge will remain constant so long as the conditions at or near the gaging station remain constant;

(2) Neglecting the change of slope due to the rise and fall of the stream, the discharge will be the same whenever the stream is at a given stage; and

(3) The discharge is both a function of, and increases gradually with, the gage heights. (2 and 3 depend on 1.)

As the beds of many streams are changeable, the problem divides itself into two classes: (1) Those of streams with permanent or practically permanent beds, and (2) those of streams with changeable beds. The base data and methods of obtaining them are the same for either class, and it is only in the computation of the mean daily flow that different methods are necessary.

In determining the daily discharge of streams with permanent beds, the results of the discharge measurements are plotted on cross-section paper, with gage heights as ordinates and discharges as abscissas.

Through these points a smooth curve is drawn, which shows the discharge for any gage height, and from which a rating table is prepared. The mean velocity and area determined for each discharge measurement are also plotted. Through these points the curves of mean velocity and of area are drawn, and the rating curve is largely determined by taking the product of the mean velocity and the area at various stages as determined by these curves. These curves of mean velocity and area are of special value in determining the location of the rating curve for stages at which actual discharge measurements are not available and for extending the discharge curve outside the limits of the measurements. In the preparation of the rating table the discharge for each tenth or half-tenth on the gage is found from the curve. The first and second differences of these discharges are then taken and adjusted according to the law that they shall either be constant or increasing, never decreasing. The discharges in the table are then changed in accordance with these adjusted differences. In making up the station rating curve the individual discharge measurements and the conditions under which they were taken are carefully studied, in order that proper weight shall be given to each measurement. Rating curves in general take the form of a parabola, and as a rule the high-water portion of the curve approaches a straight line. For stations of permanent character the results of the measurements from year to year should be within 5 per cent of the curve, with the exception of those taken during high water, when the probable error may be as high as 10 per cent.

The determination of the daily discharge of streams with changeable beds is difficult, and unless frequent discharge measurements are made the results obtained are only roughly approximate. For streams with continually shifting beds, such as Colorado River and the Rio Grande, discharge measurements are made every two or three days, and the discharges for the intervening days are obtained by interpolation, modified by the gage heights for these days. For stations with beds which shift slowly, or are only materially changed during floods, station rating curves and tables can be prepared for the periods between changes, and satisfactory results can be obtained with two or three measurements a month, providing measurements are taken soon after the changes occur.

In determining the flow for periods when the streams are frozen, special rating curves and tables have to be prepared from measurements taken under these conditions. The methods of constructing these curves and tables are the same as for open sections. The discharge measurements, however, are either taken by integration in verticals or by the vertical velocity-curve method, as sufficient experiments have not been made on ice-covered streams to determine the laws which govern the position of the thread of mean velocity.

The Report of Progress of Stream Measurements for the Calendar Year 1904, of which this is Part II, is published in a series of twelve Water-Supply Papers, Nos. 124–135, inclusive, under the following subtitles:

Part 1. Atlantic coast of New England drainage.
Part 2. Hudson, Passaic, Raritan, and Delaware River drainages.
Part 3. Susquehanna, Patapsco, Potomac, James, Roanoke, Cape Fear, and Yadkin River drainages.
Part 4. Santee, Savannah, Ogeechee, Altamaha rivers, and Eastern Gulf of Mexico drainage.
Part 5. Eastern Mississippi River drainage.
Part 6. Great Lakes and St. Lawrence River drainage.
Part 7. Hudson Bay, Minnesota, Wapsipinicon, Iowa, Des Moines, and Missouri River drainages.
Part 8. Platte, Kansas, Meramec, Arkansas, and Red River drainages.
Part 9. Western Gulf of Mexico drainage.
Part 10. Colorado River and Great Basin drainage.
Part 11. The Great Basin and Pacific Ocean drainage in California.
Part 12. Columbia River and Puget Sound drainage.

The territory covered by each paper is given in the subtitle, and the larger drainages are, for convenience in arrangement, subdivided into smaller ones, under which the data are arranged, as far as practicable, geographically.

These papers contain the data that have been collected at the regular gaging stations, the results of the computations based upon the observations, and such other information that has been collected that has a direct bearing on these data, including, as far as practicable, descriptions of the drainage areas and the streams draining them.

For each regular station are given, as far as available, the following data:

1. Description of station.
2. List of discharge measurements.
3. Gage-height table.
4. Rating table.
5. Table of estimated monthly and yearly discharges and run-off.

The descriptions of stations give, as far as possible, such general facts about the locality and equipment as would enable the reader to find the station and use the same. They also give, as far as possible, a complete history of all the changes that have occurred since the establishment of the station that would be factors in using the data collected.

The discharge-measurement table gives the results of the discharge measurements made during the year. This includes the date, the hydrographer's name, the gage height, and the discharge in second-feet.

The table of daily gage heights gives for each day the mean height of the surface of the river as found from the mean of the gage read-

ings taken on that day. At most of the stations the gage is read in the morning and in the evening.

The rating table gives discharges in second-feet corresponding to each stage of the river as given by the gage heights.

In the table of estimated run-off the column headed "Maximum" gives the mean flow for the day when the mean gage height was the highest, and it is the flow as given in the rating table for that mean gage height. As the gage height is the mean for the day, there might have been short periods when the water was higher and the corresponding discharge larger than given in this column. Likewise in the column of "Minimum" the quantity given is the mean flow for the day when the mean gage height was lowest. The column headed "Mean" gives the average flow for each second during the month. Upon this mean the computations for the three remaining columns which are defined on page 14 are based.

In the computations for the tables of this report the following general and special rules have been used:

Fundamental rules for computation.

1. The highest degree of precision consistent with the rational use of time and money is imperative.

2. All items of computation should, in general, be expressed by at least two and by not more than four significant figures.

3. Any measurement in a vertical velocity, mean velocity, or discharge curve whose per cent of error is 5 times the average per cent error of all the other measurements should be rejected.

4. In reducing the number of significant figures, or the number of decimal places, by dropping the last figure, the following rules apply:

(a) When the figure in the place to be rejected is less than 5, drop it without changing the preceding figure. Example: 1,827.4 becomes 1,827.

(b) When the figure in the place to be rejected is greater than 5, drop it and increase the preceding figure by 1. Example: 1,827.6 becomes 1,828.

(c) When the figure in the place to be rejected is 5, and it is preceded by an even figure, drop the 5. Example: 1,828.5 becomes 1,828.

(d) When the figure in the place to be rejected is 5, and it is preceded by an odd figure, drop the 5 and increase the preceding figure by 1. Example: 1,827.5 becomes 1,828.

5. In constructing and applying rating tables a maximum limit of one-half per cent error should seldom be exceeded.

Special rules for computation.

1. Rating tables are to be constructed as close as the data upon which they are based will warrant. No decimals are to be used when the discharge is over 50 second-feet.

2. Daily discharges shall be applied directly to the gage heights as they are tabulated.

3. Monthly means are to be carried out to one decimal place when the quantities are below 100 second-feet. Between 100 and 10,000 second-feet, the last figure in the monthly mean shall be a significant figure. This also applies to the yearly mean.

4. Second-feet per square mile and depth in inches for the individual months shall be carried out at least to three significant figures, except in the case of decimals,

where the first significant figure is preceded by one or more naughts (0), when the quantity shall be carried out to two significant figures. Example: 1.25; .125; .012; .0012. The yearly means for these quantities are always to be expressed in three significant figures and at least two decimal places.

The results of the stream measurements made during previous years by the United States Geological Survey can be found in the following Survey publications. A detailed index of these reports (from 1888–1903) is given in Water-Supply Paper No. 119.

1888. Tenth Annual Report, Part II.
1889. Eleventh Annual Report, Part II.
1890. Twelfth Annual Report, Part II.
1891. Thirteenth Annual Report, Part III.
1892. Fourteenth Annual Report, Part II.
1893. Bulletin No. 131.
1894. Bulletin No. 131; Sixteenth Annual Report, Part II.
1895. Bulletin No. 140.
1896. Water-Supply Paper No. 11; Eighteenth Annual Report, Part IV.
1897. Water-Supply Papers Nos. 15 and 16; Nineteenth Annual Report, Part IV.
1898. Water-Supply Papers Nos. 27 and 28; Twentieth Annual Report, Part IV.
1899. Water-Supply Papers Nos. 35 to 39, inclusive; Twenty-first Annual Report, Part IV.
1900. Water-Supply Papers Nos. 47 to 52, inclusive; Twenty-second Annual Report, Part IV.
1901. East of Mississippi River, Water-Supply Papers Nos. 65 and 75.
West of Mississippi River, Water-Supply Papers Nos. 66 and 75.
1902. East of Mississippi River, Water-Supply Papers Nos. 82 and 83.
West of Mississippi River, Water-Supply Papers Nos. 84 and 85.
1903. East of Mississippi River, Water-Supply Papers Nos. 97 and 98.
West of Mississippi River, Water-Supply Papers Nos. 99 and 100.
1904. East of Mississippi River, Water-Supply Papers Nos. 124 to 129, inclusive.
West of Mississippi River, Water-Supply Papers Nos. 130 to 135, inclusive.

A limited number of these are for free distribution, and as long as the supply lasts they may be obtained by application to the Director United States Geological Survey or to members of Congress. Other copies are filed with the Superintendent of Public Documents, Washington, D. C., from whom they may be had at prices slightly above cost. Copies of Government publications are, as a rule, furnished to the public libraries in our large cities, where they may be consulted by those interested.

COOPERATION AND ACKNOWLEDGMENTS.

Most of the measurements presented in this paper have been obtained through local hydrographers. Acknowledgment is extended to other persons and corporations who have assisted local hydrographers or have cooperated in any way, either by furnishing records of the height of water or by assisting in transportation.

The following list, arranged alphabetically by States, gives the names of the resident hydrographers and others who have assisted in furnishing and preparing the data contained in this report:

New Jersey.—District hydrographer, E. G. Paul during first half and N. C. Grover[a] during the last half of the year, assisted by H. D. Comstock.

New York.—District hydrographer, R. E. Horton,[b] assisted by C. C. Covert. Records have been furnished by the following: E. A. Fisher, city engineer, and John F. Skinner, special assistant engineer, Rochester, N. Y.; T. P. Yates, Waverly, N. Y.; William S. Bacot, Utica, N. Y.; International Paper Company, Fort Edward, N. Y.; Schroon River Pulp and Paper Company, Warrensburg, N. Y.; Duncan Company, R. P. Bloss, Mechanicsville, N. Y.; George Beebe, deputy city engineer, Syracuse, N. Y. Special acknowledgment is made of the interest and assistance of Hon. Edward A. Bond, State engineer, and William Pierson Judson, deputy State engineer.

Pennsylvania.—District hydrographer, E. G. Paul during first half and N. C. Grover during the last half of the year, assisted by H. D. Comstock. Special acknowledgment is due to Mr. John E. Codman for the records of flow of the streams in the vicinity of Philadelphia.

HUDSON RIVER DRAINAGE BASIN.

HUDSON RIVER AT FORT EDWARD, N. Y.

This station, which is located at the dam of the International Paper Company, was established in 1895, in connection with the upper Hudson storage surveys.[c] The dam is of framed timber on slate-rock foundation, and has but little leakage. The crest is straight, very nearly level, and 587.6 feet in length. The crest gage zero stands at the level of the lip of the dam proper. Flashboards are usually maintained on the dam from 15 inches to 18 inches in height. A record is kept of the height of flashboards, and of the times of their setting and removal.

There are 62 water wheels in the adjoining mill. These are nearly all of modern types, which have been tested at the Holyoke flume. A record is kept of the daily run of each in hours, as well as of the working head, which is usually 19 feet. The discharge through the turbines is taken from diagrams expressing the flow as a function of the working head and number of wheel-hours run.

In the winter of 1896–97 a flood spillway was cut around the south end of the dam, over which the water begins to flow whenever it reaches the level of the crest of the flashboards. The profile of the spillway is very irregular and causes some uncertainty in the calculated flow during times of high water.

Whenever the flashboards are off from the main dam the flow is computed by means of coefficients derived from the United States Geological Survey experiments on a model dam of similar cross section.

With the flashboards on, the flow has been computed by the Francis formula for the thin-edged weir. During the dry season but little water passes over the dam, the entire flow being employed to drive the turbines.

---

[a] The office of the district hydrographer for New Jersey and Pennsylvania is at the United States Geological Survey, Washington, D. C.

[b] The office of the district hydrographer for New York is 75 Arcade, Utica, N. Y.

[c] See Report of State Engineer and Surveyor of New York, 1895, p. 105.

A new and accurate profile of the crest of the dam, obtained in 1903, has been used to determine the discharge for 1903 and 1904.

During the navigation season water is diverted from Hudson River at Glens Falls feeder dam, 7 miles above Fort Edward, for the supply of Champlain Canal.

The Champlain Canal feeder was measured at Glens Falls on August 25, 1904, giving a discharge of 302 second-feet.

The drainage area tributary to the Hudson above Fort Edward is 0.62 of that of the same stream above Mechanicsville gaging station. The principal intervening tributaries are Hoosic River and Batten Kill, having drainage areas of 730 and 460 square miles, respectively.[a]

The observations at this station during 1904 have been made under the direction of R. E. Horton, district hydrographer.

Mean daily discharge, in second-feet, of Hudson River at Fort Edward, N. Y., for 1903 and 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1903.												
1	4,460	b6,800	b9,500	10,640	3,840	2,380	6,460	2,070	5,990	2,940	b4,430	b2,840
2	4,260	6,460	12,680	10,640	1,640	2,310	6,460	b3,820	5,810	2,940	5,140	4,520
3	2,100	5,980	10,800	8,970	b2,160	2,510	6,160	4,800	5,240	1,660	4,590	3,880
4	b8,820	5,980	10,800	6,840	4,250	2,350	b6,050	4,800	4,540	1,370	4,860	4,020
5	4,980	6,840	9,560	b6,330	4,560	2,350	b6,050	5,060	1,430	2,940	4,860	2,200
6	4,810	6,840	8,880	11,840	4,420	1,520	5,410	5,810	b2,840	3,440	4,860	a710
7	4,460	4,300	8,040	10,800	3,510	b600	4,550	5,990	b3,420	3,810	2,870	2,990
8	4,530	b5,130	b14,030	10,040	4,560	2,920	4,390	4,090	3,580	4,060	b2,460	3,880
9	4,170	5,980	17,680	8,880	2,250	3,260	4,220	b5,130	3,720	4,440	4,440	3,880
10	1,870	4,980	17,680	8,880	b1,980	3,260	3,800	5,810	3,720	16,600	4,300	3,630
11	b8,820	4,810	17,520	5,750	3,460	3,260	2,010	5,990	3,720	b16,340	4,300	3,750
12	3,620	6,160	17,520	b6,800	2,950	3,880	b2,460	6,290	2,050	13,500	4,300	1,940
13	3,840	6,160	17,520	7,820	2,440	5,060	4,030	7,250	b2,460	10,800	4,300	b2,460
14	3,860	4,000	15,430	7,210	2,440	b6,050	4,200	7,040	3,280	10,800	2,460	4,060
15	4,100	b6,330	b17,360	4,980	2,830	12,050	4,200	4,090	2,780	8,420	b2,460	3,810
16	4,260	5,660	16,460	5,260	1,660	7,350	4,310	b6,050	2,390	7,200	4,060	3,810
17	2,100	5,260	14,380	5,260	b1,260	5,910	4,200	4,290	2,700	3,380	4,200	3,940
18	b2,460	4,980	14,380	6,840	2,670	9,490	2,130	3,540	3,080	8,120	4,620	3,810
19	3,540	4,710	15,540	b6,800	2,670	9,120	b2,460	3,360	1,740	11,320	4,260	2,000
20	3,380	4,710	18,020	5,260	3,830	3,710	3,690	b780	b2,460	10,320	4,260	b2,160
21	3,540	2,550	17,380	4,260	b3,540	11,550	3,690	b360	3,030	10,320	1,880	4,560
22	4,130	6,960	b23,960	4,210	2,920	16,640	4,310	1,640	2,890	8,880	b2,460	4,000
23	4,170	5,710	27,710	4,040	1,330	15,860	5,980	b3,820	2,390	8,880	b4,300	4,000
24	2,100	4,010	b35,780	4,040	b990	14,680	6,460	4,640	2,640	5,520	b4,300	4,000
25	b8,820	4,010	b34,890	1,750	b2,070	13,690	4,170	4,390	2,640	4,880	b2,460	b3,920
26	4,360	4,010	28,760	b2,840	b1,610	13,080	b6,050	4,840	1,540	4,980	b2,460	b3,920
27	4,260	2,010	22,060	3,740	b1,610	11,880	6,460	4,840	b2,460	4,980	b2,840	b3,920
28	4,100	b5,320	15,750	3,740	b1,430	10,940	4,710	4,840	2,890	4,530	b2,840	4,400
29	4,080	.....	b18,060	3,740	1,610	10,040	4,030	2,770	2,640	4,060	b3,210	4,400
30	4,360	.....	10,290	3,740	1,220	7,820	4,030	b5,130	2,390	4,080	b3,210	4,400
31	2,200	.....	9,910	.....	b1,670	.....	4,030	5,740	.....	1,900	.....	4,400

a Water power of upper Hudson River is described in Report of New York State Engineer and Surveyor, 1895, pp. 124-164.

b Sundays, holidays, and for repairs, mills shut down.

Mean daily discharge, in second-feet, of Hudson River at Fort Edward, N. Y., etc.—Cont'd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1904.												
1	6,620	3,020	3,080	13,240	a21,380	4,020	3,030	3,620	2,210	3,310	5,050	2,410
2	4,430	2,750	3,120	10,800	22,660	4,430	2,310	2,200	2,220	a7,450	4,960	2,530
3	a3,210	2,900	3,380	a13,330	21,540	4,130	830	2,830	1,770	6,180	4,160	1,140
4	5,960	2,640	3,490	13,540	20,120	3,890	(a)	2,340	a1,200	4,820	3,920	a2,190
5	5,870	2,640	2,610	14,080	19,740	a9,200	3,030	2,330	a2,810	5,190	1,870	2,710
6	5,620	1,910	a2,460	16,340	17,320	8,890	3,420	4,150	3,810	4,490	a2,800	1,810
7	5,990	a2,460	3,950	16,340	13,630	7,980	3,030	a3,990	2,190	3,480	3,670	2,160
8	6,120	3,610	4,200	18,380	a16,120	6,000	2,780	3,860	3,010	1,520	3,260	2,720
9	4,790	4,280	7,420	18,370	11,820	5,690	2,210	2,340	2,530	a3,010	3,120	2,160
10	a2,460	4,530	8,040	a27,630	11,820	11,240	(a)	2,520	1,750	3,620	2,910	1,020
11	5,460	4,440	8,420	31,620	8,410	9,810	2,410	2,720	a2,010	3,860	3,280	a1,780
12	5,210	4,360	7,010	29,480	6,300	a13,400	2,160	2,810	2,780	5,510	2,070	2,740
13	5,120	3,020	a7,820	26,560	6,300	8,440	2,280	1,940	2,220	5,380	a2,800	2,160
14	5,120	a5,130	4,900	25,380	4,860	7,350	2,780	a1,730	2,840	5,050	3,980	2,530
15	5,370	4,030	4,620	17,320	a10,090	6,940	2,910	2,230	2,230	2,680	2,660	2,160
16	4,290	3,900	4,980	12,630	6,300	6,000	2,030	2,060	2,230	a3,990	2,660	2,160
17	a2,160	3,680	4,170	a11,680	7,190	4,430	(a)	1,460	1,910	4,290	2,660	1,220
18	5,030	3,090	4,260	11,280	7,890	2,810	2,410	1,770	a1,510	3,560	2,410	a1,780
19	4,650	2,430	2,840	11,000	7,390	a1,700	2,410	1,950	3,550	3,220	1,220	2,190
20	4,410	1,840	a2,460	9,280	7,620	3,180	1,910	1,280	2,710	3,510	a2,490	2,600
21	4,160	a3,820	4,360	8,820	6,330	3,180	2,160	a450	2,730	3,730	3,080	2,080
22	4,520	3,630	4,210	7,190	a9,540	3,180	1,780	6,330	2,730	14,020	2,030	1,910
23	3,550	3,540	5,980	4,750	7,190	3,180	1,710	6,820	2,740	a20,510	2,580	2,060
24	a3,210	3,790	11,280	a10,090	6,300	3,160	(a)	6,660	2,020	16,780	1,640	980
25	6,240	3,930	13,540	15,680	5,950	1,040	1,780	4,840	a2,980	13,840	2,230	a2,740
26	6,240	3,840	11,820	15,680	5,950	a1,540	1,410	4,450	4,540	11,160	1,140	a2,660
27	6,120	2,390	a16,810	13,540	6,300	3,000	1,410	2,450	4,350	9,480	a2,010	2,990
28	6,120	a3,820	16,340	13,540	4,860	2,440	1,660	a2,030	4,680	7,980	3,580	3,220
29	6,120	3,260	13,240	21,540	a6,000	1,180	2,160	2,660	4,680	4,850	2,780	3,740
30	4,920	.....	13,240	21,740	5,950	1,280	1,480	2,320	4,150	a7,450	2,280	3,740
31	a2,460	.....	13,240	.....	5,300	.....	(a)	2,270	.....	5,720	.....	1,560

a Sundays, holidays, for repairs, mills shut down.

Estimated monthly discharge of Hudson River at Fort Edward, N. Y., for 1903 and 1904.

[Drainage area, 2,800 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1903.					
January	4,980	1,870	3,728	1.33	1.53
February	6,960	2,010	5,238	1.87	1.95
March	35,780	8,040	17,040	6.09	7.02
April	11,840	1,750	6,398	2.28	2.54
May	4,560	990	2,561	.915	1.05
June	16,640	600	7,184	2.57	2.87
July	6,460	2,010	4,554	1.63	1.88
August	7,250	360	4,486	1.60	1.84
September	5,990	1,430	3,080	1.10	1.23
October	16,600	1,370	6,691	2.39	2.76
November	5,140	1,880	3,733	1.33	1.48
December	4,560	710	3,546	1.27	1.46
The year	35,780	360	5,687	2.03	27.61
1904.					
January	6,620	2,160	4,889	1.75	2.02
February	5,130	1,840	3,403	1.22	1.27
March	16,810	2,460	7,009	2.50	2.88
April	31,620	4,750	16,030	5.72	6.38
May	22,660	4,860	10,250	3.66	4.22
June	13,400	1,040	5,090	1.82	2.03
July, 26 days	3,420	830	[a]2,211	.790	.911
August	6,820	450	2,949	1.05	1.21
September	4,680	1,200	2,753	.983	1.10
October	20,510	1,520	6,440	2.30	2.65
November	5,050	1,140	2,843	1.02	1.14
December	3,740	980	2,248	.803	.926
The year	31,620	450	5,510	1.97	26.74

[a] Mean for 26 days taken as mean for entire month.

HUDSON RIVER AT MECHANICSVILLE, N. Y.

A record of the flow of Hudson River at Mechanicsville has been kept by the Duncan Company, beginning December, 1888. The record includes two daily readings of the depth on the crest of the dam, and a continuous record of the run of the water wheels in the adjoining paper mill. The accompanying tables show the monthly and daily

mean flow at Mechanicsville, computed by Mr. R. P. Bloss, the engineer of the company. The flow over the dam has heretofore been computed by the Francis formula for the Merrimac dam:

$$Q=3.012\ L\ H^{1.53}.$$

L being 794 feet. H=depth on crest of dam in feet. The same formula has been used in all cases, whether flashboards are on or off.

The water supply of Champlain Canal is drawn from Hudson River, above Mechanicsville; the gagings at Mechanicsville do not therefore represent precisely the natural yield of the drainage basin.

During 1904 the dam has been increased in height by the addition of a rounded concrete crest, raised to the height of the flashboards formerly used. A new apron has also been constructed. These changes have caused a break in the record. A new discharge table for the dam is being prepared, using coefficients derived from the experiments of the United States Geological Survey at Cornell University, and the record will be continued as formerly.

The observations at this station during 1904 have been made under the direction of R. E. Horton, district hydrographer.

Mean daily discharge, in second-feet, of Hudson River at Mechanicsville, N. Y., for 1904.

Day.	Jan.	Feb.	Mar.	Day.	Jan.	Feb.	Mar.
1	4,410	5,770	5,770	17	7,140	5,580	.....
2	3,970	4,730	4,980	18	5,640	5,500	.....
3	5,550	4,320	6,030	19	5,510	4,270	.....
4	5,450	4,370	11,180	20	5,850	5,320	.....
5	5,350	3,560	9,130	21	4,600	6,660	.....
6	5,250	3,980	.....	22	3,390	7,310	.....
7	4,330	5,500	.....	23	9,310	11,850	.....
8	4,910	15,130	.....	24	12,970	9,780	.....
9	4,980	9,910	.....	25	9,340	7,770	.....
10	6,920	8,020	.....	26	6,800	6,700	.....
11	5,870	7,680	.....	27	5,790	6,290	.....
12	5,780	7,770	.....	28	5,190	6,450	.....
13	4,730	7,270	.....	29	4,770	6,550	.....
14	4,840	8,060	.....	30	5,070	.....	.....
15	4,550	7,380	.....	31	5,910	.....	.....
16	5,840	5,410	.....				

Estimated monthly discharge of Hudson River at Mechanicsville, N. Y., for 1904.

[Drainage area, 4,500 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	12,970	4,330	5,805	1.29	1.49
February	15,130	4,270	6,858	1.52	1.64
March, 5 days	11,180	4,930	7,408	1.65	.307

INDIAN RIVER AT INDIAN LAKE, HAMILTON COUNTY, N. Y.

A record of the stage of water in Indian Lake reservoir, located in the upper Hudson River drainage basin, as described in preceding reports, has been continued.[a] The reported stage of water in the reservoir is shown in the table below. The reservoir gates were not opened until August 13 and were closed September 28, 1904. They were again opened November 22 and remained open until December 31.

The observations at this station during 1904 have been made under the direction of R. E. Horton, district hydrographer.

Stage of water in Indian Lake reservoir, Hamilton County, N. Y., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	16.08	10.58	7.67	10.83	26.25	33.25	34.21	29.50	26.08	27.92	28.50	25.95
2	15.96	10.37	7.67	11.00	27.50	33.33	34.25	29.25	25.67	27.75	28.38	25.79
3	15.83	10.17	7.63	11.42	28.67	33.42	34.25	29.08	25.25	27.62	28.25	25.41
4	15.71	9.96	7.63	11.67	29.83	33.33	34.25	28.83	25.08	27.50	28.16	25.17
5	15.58	9.58	7.58	11.92	30.83	33.17	34.25	28.58	24.75	27.42	28.00	24.91
6	15.46	9.37	7.58	12.17	31.75	33.08	34.25	28.33	24.42	27.42	27.88	24.62
7	15.33	9.25	7.58	12.50	32.58	33.17	34.25	28.33	24.08	27.38	27.75	24.25
8	15.21	9.25	7.58	13.00	33.33	33.25	34.25	28.33	23.75	27.33	27.67	23.91
9	15.04	9.21	7.58	13.67	33.83	33.83	34.25	28.25	23.42	28.08	27.58	23.58
10	14.92	9.08	7.58	14.58	34.17	34.42	34.25	28.08	23.08	29.08	27.50	23.25
11	14.75	8.92	7.58	15.50	34.42	34.58	34.21	27.92	22.75	29.83	27.42	22.91
12	14.58	8.75	7.58	16.25	34.58	34.67	34.17	27.83	22.42	30.08	27.33	22.67
13	14.42	8.67	7.63	16.67	34.67	34.67	33.83	27.58	22.08	30.17	27.25	22.33
14	14.25	8.58	7.67	17.08	34.75	34.67	33.62	27.33	21.75	30.25	27.16	22.00
15	14.00	8.46	7.71	17.42	34.92	34.62	33.46	27.00	21.42	30.33	27.08	21.67
16	13.75	8.33	7.75	17.75	34.83	34.58	33.17	26.66	21.08	30.33	27.00	21.33
17	13.50	8.25	7.75	18.00	34.92	34.54	32.92	26.42	20.83	30.25	27.00	21.00
18	13.25	8.21	7.75	18.17	35.00	34.50	32.67	26.17	20.58	30.33	27.00	20.75
19	13.00	8.17	7.71	18.33	34.83	34.46	32.46	26.00	20.33	30.50	27.00	20.45
20	12.83	8.08	7.67	18.58	34.92	34.42	32.25	26.08	20.08	30.42	26.96	20.17
21	12.67	8.00	7.63	18.75	34.92	34.42	32.08	26.17	19.75	30.33	26.92	19.88
22	12.50	7.92	7.58	18.92	34.79	34.42	31.92	26.17	19.50	30.16	26.83	19.58
23	12.33	7.83	7.67	19.17	34.58	34.42	31.67	26.25	19.25	29.96	26.79	19.33
24	12.17	7.75	7.83	19.42	34.33	34.37	31.50	26.33	19.00	29.75	26.75	19.08
25	12.00	7.75	8.17	20.17	34.00	34.25	31.33	26.42	19.00	29.62	26.71	18.83
26	11.83	7.75	8.50	21.00	33.79	34.17	31.17	26.46	19.17	29.42	26.67	18.58
27	11.63	7.75	9.08	21.75	33.46	34.17	30.92	26.50	19.21	29.25	26.33	18.33
28	11.42	7.71	9.58	22.75	33.08	34.17	30.58	26.50	19.17	29.08	25.83	18.04
29	11.21	7.67	9.92	23.92	33.00	34.17	30.33	26.54	19.25	28.92	25.42	17.83
30	11.00	.....	10.25	25.17	33.08	34.17	30.08	26.54	19.67	28.75	25.00	17.58
31	10.79	.....	10.50	.....	33.17	.....	29.83	26.33	.....	28.62	.....	17.33

HOOSIC RIVER AT BUSKIRK, N. Y.

A gaging station was established at the highway bridge in Buskirk village, September 25, 1903. The gage is read twice each day by Bert C. Henry, from a chain gage attached to the bridge. Hoosic River has its headwaters on the west slope of the Hoosic Mountains in Ver-

[a] See also Report on Stream Gagings, contained in Supplement, Report of State Engineer and Surveyor, 1902, pp. 230 to 234.

mont and Massachusetts. Two head branches, one flowing southward, the other northward along the west slope of this range, join at North Adams, Mass. The stream then flows in a northwestern direction, entering Hudson River 3 miles north of Mechanicsville. The drainage basin above Buskirk is rugged and precipitous, the distribution of tributaries affording rapid concentration of the run-off from the steep rock slopes. The soil is generally firm and tenacious in the valleys. The ridges are sparsely wooded. The general elevation of the valley at the junction of the headwaters is 1,000 feet. Numerous dams, affording power for textile, agricultural-implement, and other industries, are scattered throughout the length of the stream from North Adams to Schaghticoke.[a] There are no important lakes and but one storage reservoir in the drainage basin, this being at Farnam, near the head of the South Branch.

The State boundary to the south of Hoosic River follows the Taconic Ridge, which forms the divide between the Hoosic in Massachusetts and Little Hoosic River in New York.

The observations at this station during 1904 have been made under the direction of R. E. Horton, district hydrographer.

Drainage areas of Hoosic River.[a]

Location.	Area, place to place.	Total square miles.
Above junction branches, North Adams, Mass	118.8	118.8
Above New York State line	115.6	234.4
Above Hoosic Falls	118.5	352.9
Above mouth Walloomsac River	2.6	355.5
Walloomsac River, above mouth	159.0	514.5
Above Buskirk	64.1	578.6
Above Schaghticoke	56.7	635.3
Above mouth	80.5	715.8

[a] From United States Geological Survey Topographic Atlas, the drainage basin being shown on the Taconic, Mettawee, and Cohoes sheets.

Discharge measurements of Hoosic River at Buskirk, N. Y., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Sq. feet.	*Ft. per sec.*	*Feet.*	*Second-feet.*
March 2[b]	C. C. Covert	564	0.79	3.29	446
July 27	do	314	.71	1.60	225
August 26	H. R. Beebe	336	.88	1.75	294
October 6	A. M. Evans	398	1.23	2.11	489
November 10	H. R. Beebe	387	1.23	2.09	475

[a] Water power as it existed in 1880 is described in Tenth Census, 1880, vol. 16, pt. 1, pp. 375–380.
[b] River frozen over below bridge. Probable backwater.

timber cribbing 50 feet above the lower section of the dam, with its zero mark at elevation 172.00 referred to the United States Deep Waterways datum. Gage readings are taken twice daily, at intervals of about 12 hours, by Robert Wilson. The mean of the two daily readings is used in computing the flow. The discharge over the main dam has been calculated by means of the weir formula, using coefficients derived from the United States Geological Survey experiments. During high water the current of the stream through the cross section of the channel leading to the lower dam has a velocity of several feet per second. The head due to this velocity has been added to the observed head as a correction for velocity of approach to the lower dam. The upper dam is situated 450 feet upstream from the crest gage.

The observations at this station during 1904 have been made under the direction of R. E. Horton, district hydrographer.

Mean daily discharge, in second-feet, of Mohawk River at Dunsbach Ferry Bridge, N. Y., for 1903 and 1904.

Day.	Jan.[a]	Feb.[a]	Mar.[b]	Apr.[b]	May.[b]	June.[b]	July.[b]	Aug.[a]	Sept.[a]	Oct.	Nov.	Dec.
1903.												
1			39,310	27,350	1,950	2,320	7,830			1,520	3,760	2,760
2			29,490	18,850	1,850	2,320	7,440			1,760	3,560	2,760
3			23,630	13,870	1,950	2,320	6,850			1,870	3,430	2,760
4			21,370	18,510	2,450	2,560	6,630			1,980	3,430	2,760
5			16,490	13,550	2,150	2,700	3,350			2,600	3,100	2,760
6			15,510	13,270	2,090	2,900	2,650			2,930	3,680	2,760
7			16,830	11,770	2,150	2,940	2,870			3,760	4,540	2,760
8			21,750	23,170	2,028	3,080	3,350			6,680	3,900	2,760
9			39,310	24,430	2,028	2,970	3,918			29,990	3,350	2,430
10			36,150	18,850	2,030	3,230	3,410			[c]84,880	2,990	2,430
11			50,790	12,370	1,910	4,490	3,440			43,210	3,020	2,100
12			46,670	12,050	1,810	8,850	5,580			30,770	3,350	2,100
13			39,310	9,850	1,810	13,030	5,380			21,310	3,300	1,860
14			35,190	6,350	1,750	12,710	4,690			13,730	2,910	2,600
15			29,490	6,810	1,750	11,550	4,980			8,440	3,020	3,280
16			27,370	7,310	1,660	11,550	4,920			7,680	3,020	3,430
17			19,950	8,810	1,660	9,890	5,070			6,680	4,380	3,260
18			18,850	7,310	1,580	7,590	5,008			9,280	12,170	3,100
19			17,830	5,890	1,580	8,180	4,890			14,690	11,240	3,760
20			18,150	5,670	1,620	11,400	5,160			13,110	7,920	6,420
21			19,950	5,388	1,620	19,950	5,490			11,240	6,170	9,280
22			22,890	5,188	1,620	29,050	6,850			9,280	4,360	11,860
23			31,250	5,188	1,470	22,510	18,850			6,930	3,650	8,440
24			35,190	4,830	1,310	22,890	14,230			6,170	4,060	7,430
25			52,950	3,330	1,200	23,630	12,430			5,920	3,840	6,930
26			32,590	3,210	1,200	23,630	9,890			5,270	3,760	6,420
27			21,750	3,070	1,200	13,930	7,590			5,060	3,590	5,270
28			24,850	2,450	1,270	10,970	7,110			4,620	2,930	4,620
29			14,170	2,090	1,430	9,890	6,630			4,410	2,760	3,590
30			12,110	1,950	1,620	7,110	6,630			4,190	2,930	3,590
31			19,230		2,120		6,390			4,190		3,550

[a] Record not available.
[b] Record approximate, dam in injured condition.
[c] Maximum somewhat greater. Approximate owing to back water.

age area of 1,306 square miles. In calculating the discharge for 1903 and 1904 use has been made of the experiments of the United States Geological Survey at Cornell University, 1903, on flow over dams.

The observations at this station during 1904 have been made under the direction of R. E. Horton, district hydrographer.

Mean daily discharge, in second-feet, of Mohawk River at Little Falls, N. Y., for 1903 and 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1903.												
1	1,869	5,705	13,520	8,025	1,041	675	3,005	1,523	2,045	1,106	1,710	1,440
2	1,670	6,243	14,130	7,203	2,002	675	3,722	1,270	1,575	1,072	1,429	1,344
3	2,179	6,419	12,610	5,863	1,067	578	2,582	1,183	1,312	935	1,333	1,346
4	4,119	6,439	8,943	8,573	1,150	652	1,835	1,479	1,533	1,012	1,294	1,346
5	5,011	7,145	6,940	7,907	1,154	629	1,525	4,762	1,275	2,042	1,661	1,344
6	4,451	6,278	5,885	6,218	1,197	573	2,138	4,090	1,488	2,776	2,468	1,043
7	3,084	6,026	5,940	6,114	1,148	540	2,778	3,340	746	2,424	2,133	1,266
8	2,473	4,512	7,971	7,866	1,148	629	1,442	2,901	851	2,498	1,608	1,268
9	2,088	3,406	14,510	7,414	1,078	819	1,346	855	821	10,510	1,529	1,065
10	1,633	2,949	16,740	8,011	850	1,023	1,140	2,835	821	20,260	1,528	885
11	1,347	2,836	22,310	7,190	974	870	1,268	2,477	991	17,960	1,346	961
12	1,388	4,086	20,800	5,921	1,022	2,141	834	5,440	1,221	11,940	1,346	1,265
13	1,250	5,722	16,260	5,724	1,022	5,462	964	4,166	966	7,133	1,343	1,279
14	1,552	5,591	11,480	4,372	953	3,816	1,033	2,830	927	5,297	1,343	1,348
15	1,755	3,812	9,412	3,783	988	2,745	999	2,288	1,140	3,396	1,292	1,348
16	1,854	3,888	8,609	3,209	816	3,048	1,068	1,039	927	2,536	1,344	1,442
17	1,773	2,598	8,118	3,209	490	2,326	1,033	1,189	1,044	2,368	3,088	1,346
18	1,334	2,143	7,636	2,741	910	2,472	921	1,189	1,434	8,225	4,768	1,266
19	1,427	1,881	7,839	2,432	1,091	2,035	753	1,033	1,562	7,589	4,580	1,227
20	1,373	2,141	8,761	2,296	988	1,666	867	1,528	1,096	6,487	2,833	1,030
21	1,556	1,900	11,680	2,422	1,022	7,453	1,349	2,968	1,100	5,215	1,878	2,540
22	2,217	1,887	13,160	2,041	910	8,297	2,038	1,934	1,066	3,610	1,658	3,282
23	2,565	2,138	8,833	1,536	877	7,125	3,606	1,309	997	1,451	1,777	3,150
24	2,135	2,188	18,040	1,354	633	6,874	4,458	1,040	962	2,586	2,087	3,210
25	1,562	2,039	16,500	1,462	628	5,841	2,776	2,633	962	2,289	2,083	3,117
26	1,807	1,764	10,330	1,662	605	5,915	2,011	6,129	798	2,039	1,442	2,617
27	1,708	1,813	7,750	1,578	557	4,992	1,487	4,991	808	1,926	1,033	1,945
28	1,646	2,316	6,384	1,310	628	2,842	2,044	3,889	857	1,727	1,346	2,136
29	1,907	.....	6,077	1,192	605	2,881	1,200	2,784	1,031	1,826	1,015	1,446
30	4,810	.....	5,216	1,074	639	1,772	1,342	1,303	1,138	1,826	1,568	1,489
31	6,026	.....	8,410	.....	400	.....	1,566	2,361	.....	1,874	.....	1,723
1904.												
1	1,588	1,771	1,841	8,499	9,601	1,927	1,181	1,072	857	6,888	1,665	1,182
2	1,428	1,613	1,792	11,200	9,474	1,490	1,784	1,072	820	4,820	1,666	1,103
3	547	1,442	1,991	9,680	7,859	1,441	1,987	1,072	998	3,079	1,539	991
4	1,189	1,343	2,787	8,471	7,735	1,090	1,701	820	1,081	2,034	1,539	579
5	1,189	1,265	3,490	8,172	7,191	2,067	1,091	733	2,097	1,818	1,399	930
6	1,068	1,265	3,173	8,192	6,787	3,023	2,354	1,604	1,526	1,883	1,134	930
7	1,268	1,421	3,307	9,347	6,137	3,034	2,194	2,392	1,233	1,878	1,361	930
8	1,346	4,672	4,970	10,250	4,522	2,171	1,452	1,392	897	1,717	1,442	930
9	1,346	4,769	5,963	14,480	3,789	6,415	1,078	1,003	936	1,505	1,079	930
10	1,176	4,597	5,432	15,860	2,581	7,322	996	1,035	1,006	2,115	1,061	866
11	1,286	4,402	5,825	17,060	2,078	4,621	1,213	983	734	7,257	1,079	440
12	1,247	4,022	5,639	12,050	2,127	2,760	1,340	758	794	7,430	934	930
13	1,247	3,731	4,403	9,557	1,660	1,880	1,304	787	794	5,447	1,091	928

Mean daily discharge, in second-feet, of Mohawk River, etc.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1904.												
14	1,331	2,914	3,368	7,580	1,820	2,027	1,177	1,166	858	3,880	1,079	930
15	1,331	2,521	2,897	6,097	1,882	1,396	1,095	850	1,226	2,659	1,081	952
16	1,282	2,402	2,369	4,764	4,658	1,536	923	850	2,036	2,101	1,048	889
17	998	1,955	2,361	4,327	4,290	1,236	956	754	1,217	1,926	1,080	818
18	1,265	1,806	2,187	4,521	2,638	969	996	732	1,082	1,528	979	874
19	1,226	1,707	2,038	4,591	2,084	1,353	1,482	856	1,429	1,485	933	889
20	1,226	1,645	2,071	3,788	2,841	1,068	1,065	2,765	1,138	1,359	820	930
21	1,265	1,418	2,471	3,203	4,476	1,033	856	8,712	2,957	4,454	932	889
22	1,265	1,707	2,827	3,138	2,922	1,115	732	6,741	2,602	8,633	1,106	930
23	1,525	2,508	4,909	3,589	2,144	1,191	682	7,162	1,667	6,866	1,002	1,001
24	2,523	2,939	3,365	4,288	1,983	1,395	1,040	5,905	1,768	4,937	1,142	1,418
25	2,937	2,706	10,870	7,568	1,968	930	990	3,875	4,042	3,263	1,182	995
26	2,649	2,409	24,220	10,070	2,227	1,870	1,131	2,238	7,310	2,690	1,070	954
27	2,521	2,229	22,110	8,227	3,320	993	1,337	1,489	4,613	2,696	819	1,480
28	2,353	1,842	16,360	10,480	4,208	823	1,346	1,235	2,948	2,696	1,069	6,340
29	2,080	1,930	10,970	10,790	4,397	794	2,530	1,063	2,151	2,530	1,069	5,068
30	1,982	.....	8,966	10,160	2,127	693	2,398	1,072	7,449	2,161	1,069	4,959
31	1,626	.....	8,359	.....	2,130	.....	1,271	890	.....	1,819	.....	4,864

Estimated monthly discharge of Mohawk River at Little Falls, N. Y., for 1903 and 1904.

[Drainage area, 1,306 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1903.					
January	6,026	1,250	2,309	1.77	2.04
February	7,145	1,764	3,777	2.89	3.01
March	22,310	5,216	10,980	8.41	9.70
April	8,573	1,074	4,323	3.31	3.70
May	2,002	400	922	.706	.814
June	8,297	540	2,912	2.23	2.49
July	4,458	753	1,778	1.36	1.57
August	6,129	855	2,541	1.95	2.25
September	2,045	746	1,116	.855	.955
October	20,260	935	4,643	3.56	4.10
November	4,768	1,015	1,862	1.43	1.60
December	3,282	885	1,662	1.27	1.46
The year	22,310	400	3,235	2.48	33.69

Estimated monthly discharge of Mohawk River at Little Falls, N. Y., etc.—Continued.

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1904.					
January	2,937	547	1,525	1.17	1.35
February	4,769	1,265	2,447	1.87	2.02
March	24,220	1,792	5,914	4.53	5.22
April	17,060	3,138	8,336	6.38	7.12
May	9,601	1,660	3,987	3.05	3.52
June	7,322	693	1,972	1.51	1.69
July	2,530	682	1,343	1.03	1.19
August	8,712	732	2,033	1.56	1.80
September	7,449	734	2,009	1.54	1.72
October	8,633	1,359	3,405	2.61	3.01
November	1,665	819	1,150	.881	.983
December	6,340	440	1,511	1.16	1.34
The year	24,220	440	2,969	2.27	30.96

MOHAWK RIVER AT DUNSBACH FERRY BRIDGE, N. Y.

This gaging record is kept at the dam of the West Troy Water Company, one-fifth mile above Dunsbach Ferry Bridge, 9 miles from the mouth of the river. The dam is in two sections, situated on opposite sides of a Hudson River shale island. The left wing at the upper end of the island has a crest length of 380 feet. The right wing, 500 feet downstream at the foot of the island, has a crest 280 feet long. The record was established March 12, 1898, for the primary purpose of checking a system of levels for the United States Board of Engineers on Deep Waterways, by D. J. Howell, civil engineer, who has furnished the earlier portion of the record. No record was kept from April 1, 1899, to August 1, 1900. In the pumping station adjoining the dam are two turbines of the old American type, one 66 inches and the other 75 inches in diameter. A new 54-inch Victor turbine was installed during 1902. The discharge is calculated from the recorded daily run of the water wheels and working head. The turbines drive pumps taking water from the river for water-supply purposes at the rate of 1,500,000 gallons per day, equivalent to a continuous flow of 2¼ second-feet. The capacity is being increased. The dam is of masonry, with a flat granite crest 5.5 feet wide. It was rebuilt in 1903 and a new profile obtained. The crest gage is attached to the

timber cribbing 50 feet above the lower section of the dam, with its zero mark at elevation 172.00 referred to the United States Deep Waterways datum. Gage readings are taken twice daily, at intervals of about 12 hours, by Robert Wilson. The mean of the two daily readings is used in computing the flow. The discharge over the main dam has been calculated by means of the weir formula, using coefficients derived from the United States Geological Survey experiments. During high water the current of the stream through the cross section of the channel leading to the lower dam has a velocity of several feet per second. The head due to this velocity has been added to the observed head as a correction for velocity of approach to the lower dam. The upper dam is situated 450 feet upstream from the crest gage.

The observations at this station during 1904 have been made under the direction of R. E. Horton, district hydrographer.

Mean daily discharge, in second-feet, of Mohawk River at Dunsbach Ferry Bridge, N. Y., for 1903 and 1904.

Day.	Jan.[a]	Feb.[a]	Mar.[b]	Apr.[b]	May.[b]	June.[b]	July.[b]	Aug.[a]	Sept.[a]	Oct.	Nov.	Dec.
1903.												
1	.....	.....	39,310	27,350	1,950	2,320	7,830	.....	.....	1,520	3,760	2,760
2	.....	.....	29,490	18,850	1,850	2,320	7,440	.....	.....	1,760	3,560	2,760
3	.....	.....	23,630	13,870	1,950	2,320	6,850	.....	.....	1,870	3,430	2,760
4	.....	.....	21,370	18,510	2,450	2,560	6,630	.....	.....	1,980	3,430	2,760
5	.....	.....	16,490	13,560	2,150	2,700	3,350	.....	.....	2,600	3,100	2,760
6	.....	.....	15,510	13,270	2,090	2,900	2,650	.....	.....	2,930	3,680	2,760
7	.....	.....	16,830	11,770	2,150	2,940	2,870	.....	.....	3,760	4,540	2,760
8	.....	.....	21,750	23,170	2,028	3,080	3,350	.....	.....	6,680	3,900	2,760
9	.....	.....	39,310	24,430	2,028	2,970	3,918	.....	.....	29,990	3,350	2,430
10	.....	.....	36,150	18,850	2,030	3,230	3,410	.....	.....	[c]84,880	2,990	2,430
11	.....	.....	50,790	12,370	1,910	4,490	3,440	.....	.....	43,210	3,020	2,100
12	.....	.....	46,670	12,050	1,810	8,850	5,580	.....	.....	30,770	3,350	2,100
13	.....	.....	39,310	9,850	1,810	13,030	5,380	.....	.....	21,310	3,300	1,860
14	.....	.....	35,190	6,350	1,750	12,710	4,690	.....	.....	13,730	2,910	2,600
15	.....	.....	29,490	6,810	1,750	11,550	4,980	.....	.....	8,440	3,020	3,260
16	.....	.....	27,370	7,310	1,660	11,550	4,920	.....	.....	7,680	3,020	3,430
17	.....	.....	19,950	8,810	1,660	9,890	5,070	.....	.....	6,680	4,380	3,260
18	.....	.....	18,850	7,310	1,580	7,590	5,008	.....	.....	9,280	12,170	3,100
19	.....	.....	17,830	5,890	1,580	8,180	4,890	.....	.....	14,690	11,240	3,760
20	.....	.....	18,150	5,670	1,620	11,400	5,160	.....	.....	13,110	7,920	6,420
21	.....	.....	19,950	5,388	1,620	19,950	5,490	.....	.....	11,240	6,170	9,280
22	.....	.....	22,890	5,188	1,620	29,050	6,850	.....	.....	9,280	4,360	11,860
23	.....	.....	31,250	5,188	1,470	22,510	18,850	.....	.....	6,930	3,650	8,440
24	.....	.....	35,190	4,830	1,310	22,890	14,230	.....	.....	6,170	4,060	7,430
25	.....	.....	52,950	3,330	1,200	23,630	12,430	.....	.....	5,920	3,840	6,930
26	.....	.....	32,590	3,210	1,200	23,630	9,890	.....	.....	5,270	3,760	6,420
27	.....	.....	21,750	3,070	1,200	13,930	7,590	.....	.....	5,060	3,590	5,270
28	.....	.....	24,850	2,450	1,270	10,970	7,110	.....	.....	4,620	2,930	4,620
29	.....	.....	14,170	2,090	1,430	9,890	6,630	.....	.....	4,410	2,760	3,590
30	.....	.....	12,110	1,950	1,620	7,110	6,630	.....	.....	4,190	2,980	3,590
31	.....	.....	19,230	.....	2,120	.....	6,390	.....	.....	4,190	.....	3,560

[a] Record not available.
[b] Record approximate, dam in injured condition
[c] Maximum somewhat greater Approximate owing to back water.

Mean daily discharge, in second-feet, of Mohawk River—Continued.

Day.	Jan.[a]	Feb.[a]	Mar.[a]	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1904.												
1	2,760	1,870	3,570	18,870	21,460	3,760	2,460	2,760	2,020	7,940	3,430	2,930
2	2,430	1,640	3,680	30,940	18,870	3,430	2,760	2,430	1,790	11,860	3,430	2,430
3	2,100	1,180	4,000	30,020	16,400	3,100	2,760	2,600	1,560	8,190	3,100	2,090
4	2,100	1,180	4,150	19,610	14,690	3,100	2,430	2,600	1,790	6,680	3,100	1,880
5	2,410	910	10,320	18,130	13,730	3,260	2,760	2,270	2,520	4,620	3,100	1,870
6	2,520	950	8,920	19,240	11,860	3,590	2,740	2,100	2,190	2,930	2,760	1,870
7	2,430	950	7,860	18,870	10,960	4,190	3,090	2,760	2,100	2,760	2,760	1,760
8	2,100	2,100	8,110	24,220	9,560	4,840	2,760	3,260	1,870	2,560	2,600	1,640
9	1,870	12,480	18,790	25,020	8,720	10,400	2,430	3,100	2,100	1,870	2,430	1,640
10	1,870	5,920	15,630	31,400	7,680	18,500	2,430	2,600	2,430	2,760	2,430	1,640
11	2,070	5,060	12,720	30,940	6,930	14,040	2,100	2,100	2,270	4,620	2,430	1,870
12	2,170	4,620	11,160	27,070	5,920	9,280	2,100	1,870	2,100	7,940	2,430	1,980
13	1,720	4,190	10,320	22,250	5,060	5,700	2,600	1,690	1,980	9,280	2,270	2,100
14	1,870	3,430	8,640	16,740	4,190	4,410	2,390	1,610	2,100	7,180	2,270	2,100
15	1,640	2,760	7,600	12,800	4,410	4,190	2,270	1,610	2,270	5,660	2,270	1,980
16	1,870	1,520	6,340	11,860	5,700	3,760	1,840	1,640	2,430	5,050	2,270	1,870
17	1,870	1,180	5,410	10,960	7,430	3,760	2,060	1,520	2,100	3,830	2,270	1,870
18	1,300	1,070	5,190	10,960	6,680	3,260	2,430	1,410	2,270	2,860	2,430	1,870
19	1,180	1,160	4,540	13,110	6,170	2,760	2,590	1,410	2,270	2,760	2,600	1,870
20	1,180	950	5,190	10,680	6,170	2,430	2,890	2,930	1,870	2,760	3,100	1,760
21	1,180	930	5,620	9,000	6,930	2,100	2,270	9,560	2,270	4,110	3,260	1,640
22	1,180	960	7,600	8,440	7,180	2,270	2,080	13,730	2,760	25,980	3,760	2,760
23	1,300	870	10,600	8,720	5,920	2,100	2,060	12,170	3,980	17,420	3,430	2,100
24	1,870	840	22,960	9,000	5,060	2,230	2,100	9,560	2,930	11,550	3,260	2,270
25	5,920	900	25,740	10,680	4,620	2,350	2,100	7,430	3,100	9,000	2,930	2,430
26	3,760	1,760	35,500	17,760	3,980	2,020	2,630	5,700	5,060	6,680	2,760	2,600
27	2,760	1,410	49,470	17,080	4,620	2,020	2,380	4,190	7,180	6,420	2,700	4,620
28	2,430	950	36,790	19,240	5,270	2,020	2,320	3,590	5,920	5,920	2,430	15,030
29	2,100	950	27,290	25,820	4,840	2,010	3,260	2,600	5,270	5,490	2,600	16,740
30	2,100	.....	21,760	22,640	4,410	2,170	2,930	1,750	4,410	5,060	3,100	10,120
31	1,870	.....	19,940	.....	3,760	.....	2,760	2,090	.....	3,590	.....	8,190

[a] Record approximate owing to ice conditions.

Estimated monthly discharge of Mohawk River at Dunsbach Ferry Bridge, N. Y., for 1903 and 1904.

[Drainage area, 3,440 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1903.					
January					
February					
March [a]	52,950	12,110	27,430	7.97	9.19
April [a]	27,350	1,950	10,090	2.93	3.27
May [a]	2,450	1,200	1,738	.505	.582
June [a]	29,050	2,320	10,340	3.01	3.36
July [a]	18,850	2,650	6,404	1.86	2.14
August					
September					
October	84,880	1,520	12,070	3.51	4.05
November	12,170	2,760	4,271	1.24	1.38
December	11,860	1,860	4,188	1.22	1.41
1904.					
January	5,920	1,180	2,127	.618	.712
February	12,480	840	2,231	.649	.700
March	49,470	3,570	13,720	3.99	4.60
April	31,400	8,440	18,400	5.35	5.97
May	21,460	3,760	8,038	2.34	2.70
June	18,500	2,010	4,435	1.29	1.44
July	3,090	1,840	2,477	.720	.830
August	13,730	1,410	3,763	1.09	1.26
September	7,180	1,560	2,830	.823	.918
October	17,420	1,870	6,624	1.93	2.23
November	3,760	2,270	2,790	.811	.905
December	16,740	1,640	3,467	1.01	1.16
The year	49,470	840	5,908	1.72	23.42

[a] Record approximate.

January, February, and March, 1904, record only approximate owing to ice conditions.

ORISKANY CREEK NEAR ORISKANY, N. Y.

A gaging station was established at Wood Road Bridge, 1 mile above the village of Oriskany, June 5, 1901. A vertical board scale is read twice daily by C. H. Smith. Discharge measurements are made during low water only by fording the stream a short distance below the

bridge. The gaging station at Wood Road Bridge was discontinued November 30, 1904, and a new gaging station established at Coleman, 1 mile upstream, where a cableway has been erected for use in making current meter measurements during high water. A dam at Reeder's mills, one-fourth mile upstream, affords opportunity for checking the freshet discharge, and also affords some protection against ice which obstructs Oriskany Creek very seriously in winter. Observations at the cable station were begun August 13, 1904, and are taken twice daily by Peter Gambel. The flow of Oriskany Creek is diverted, as a whole or in part, at the State dam below the gaging station during navigation season. The dam affords opportunity to determine the freshet discharge of the stream during the spring period from the time the ice goes out until the opening of the Erie Canal. Oriskany Creek receives the inflow from storage reservoirs at the head of Chenango River.

The observations at this station during 1904 have been made under the direction of R. E. Horton, district hydrographer.

Discharge measurements of Oriskany Creek near Oriskany, N. Y., in 1904.

Date.	Hydrographer.	Area.	Mean velocity.	Gage height.	Discharge.
		Sq. feet.	*Ft. per sec.*	*Feet.*	*Second-feet.*
September 28 ..	C. C. Covert	81	1.38	0.80	112
October 7	A. M. Evans	89	1.42	.84	126
November 16 ..	H. R. Beebe	77	1.31	.68	101

Mean daily gage height, in feet, of Oriskany Creek at Coleman, N. Y., for 1904.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	0.50	0.82	1.02	0.72	17	1.60	0.68	0.82	0.65	0.45
2	.....	.88	.82	1.05	.72	18	1.78	.52	.82	.50	.40
3	.....	.72	.88	1.18	.68	19	1.60	.62	.80	.62	.38
4	.....	.52	.75	1.00	.90	20	2.04	.32	.78	.72	.72
5	.....	.65	.75	.70	.90	21	1.62	.80	2.10	.92	.30
6	.....	.62	.80	.95	.82	22	1.18	.70	1.98	.88	.45
7	.....	.62	.80	.92	.82	23	1.80	.58	1.35	.82	.42
8	.....	.58	.72	.90	.90	24	1.12	.55	1.25	.78	2.26
9	.....	.65	.72	.90	.72	25	1.95	.85	1.15	.88	.45
10	.....	.68	.90	.88	1.00	26	.85	.82	1.15	.68	.72
11	.....	.50	1.15	.85	.30	27	.78	.85	1.20	.70	.....
12	.....	.52	1.05	.60	.35	28	.68	.82	1.18	.78	.....
13	0.85	.58	.98	.75	.42	29	.70	.82	1.00	.82	.....
14	1.40	.52	.98	.78	.40	30	.62	.88	1.00	.78	.....
15	1.75	1.52	.62	.70	.35	31	.60	.....	1.12	.....	.....
16	1.68	.75	.75	.80	.30						

Mean daily gage height, in feet, of Oriskany Creek at Wood Road Bridge, near Oriskany, N. Y., for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.[a]	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	4.15	.....	4.65	4.75	2.90	1.95	1.60	1.75	1.60	1.65	1.95
2	4.05	.....	4.20	4.90	2.90	1.85	1.70	1.90	1.65	1.65	1.90
3	3.90	.....	4.80	3.80	2.70	1.90	1.60	1.75	1.85	1.65	2.05
4	3.95	.....	5.45	3.80	2.30	1.80	1.40	1.60	1.70	1.70	1.95
5	4.15	.....	4.90	3.60	2.25	2.10	1.50	1.70	1.50	1.60	1.60
6	4.40	3.90	4.95	3.50	2.55	2.00	1.75	2.20	1.55	2.00	2.05
7	4.10	5.65	5.60	4.20	2.40	1.80	1.60	1.80	1.40	1.75	1.90
8	4.35	7.75	7.30	3.90	2.30	1.70	1.45	1.70	1.50	1.55	1.90
9	4.35	6.15	6.75	4.05	2.25	2.45	1.50	1.75	1.65	1.70	1.85
10	4.35	5.30	6.10	4.15	2.20	2.35	1.60	1.65	1.60	1.90	1.90
11	3.75	4.90	5.30	3.75	2.85	1.95	1.70	1.65	1.40	2.05	2.05
12	3.25	4.70	4.95	3.95	2.10	1.80	1.75	1.65	1.50	2.10	1.65
13	3.65	4.20	4.80	3.35	2.10	1.85	1.65	1.50	1.40	2.00	1.60
14	4.10	4.20	4.90	3.15	2.05	1.75	1.50	1.65	1.40	1.70	1.80
15	4.00	3.70	4.55	3.15	3.35	1.90	1.65	1.75	2.00	1.50	1.50
16	3.90	.....	4.55	3.10	2.80	2.05	1.70	1.75	1.55	1.75	1.70
17	3.95	.....	4.80	3.20	2.30	1.70	1.50	1.50	1.50	1.60	1.80
18	3.70	.....	4.50	3.10	2.20	1.45	2.10	1.70	1.45	1.50	1.70
19	3.90	.....	4.50	3.05	2.30	1.35	1.95	1.60	1.50	1.75	1.55
20	3.70	3.40	5.45	2.90	2.80	1.50	1.55	3.15	1.60	1.65	1.65
21	3.80	3.40	5.85	2.90	2.30	1.80	1.60	2.40	1.60	3.50	1.90
22	3.95	6.40	6.30	2.80	1.95	1.65	1.55	1.95	1.65	2.65	1.85
23	5.20	5.00	7.95	2.80	1.75	1.65	2.40	2.55	1.35	2.35	1.75
24	5.10	5.00	7.50	2.60	2.05	1.55	1.80	1.90	1.75	1.95	1.70
25	4.75	4.40	7.65	2.80	1.90	1.55	1.80	1.80	1.85	1.75	1.80
26	4.55	4.05	7.30	2.60	2.00	1.45	2.10	1.85	1.75	1.90	1.90
27	4.45	3.65	5.50	2.65	2.15	1.55	1.85	1.70	1.65	1.85	1.80
28	4.45	4.15	4.00	3.40	1.90	1.55	1.95	1.55	1.70	2.05	1.90
29	4.30	5.15	3.65	3.30	1.95	1.70	2.45	1.50	1.65	2.00	2.20
30	4.30	.....	3.70	3.10	2.10	1.75	2.00	1.65	2.35	1.90	2.50
31	4.10	.....	3.70	.....	2.30	.....	1.80	1.55	.....	2.00	.....

[a] Ice conditions January 1 to March 25.

Mean daily discharge, in second-feet, of Oriskany Creek at State dam, near Oriskany, N. Y., for 1904.

Day.	Mar.	Apr.	Day.	Mar.	Apr.	Day.	Mar.	Apr.	Day.	Mar.	Apr.
1	.....	1,250	9	.....	765	17	.....	420	25	2,710	280
2	.....	1,140	10	.....	1,190	18	.....	420	26	3,855	280
3	.....	635	11	.....	730	19	.....	385	27	1,542	280
4	.....	550	12	.....	550	20	.....	350	28	780	280
5	.....	635	13	.....	550	21	.....	330	29	590	280
6	.....	875	14	.....	510	22	.....	280	30	925	280
7	.....	825	15	.....	350	23	.....	280	31	875	.....
8	.....	765	16	.....	350	24	1,340	280			

Estimated monthly discharge of Oriskany Creek near Oriskany, N. Y., for 1904.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
March 25–31	3,855	590	1,577
April	1,250	280	536

STARCH FACTORY CREEK NEAR NEW HARTFORD, N. Y.

A gaging weir was erected on this stream above the head of the former Savage reservoir May 26, 1903. The stream flows in a gulf 300 feet below the general plateau. The weir has a horizontal iron crest 6 feet in length with end contractions. The weir gage is placed 6 feet upstream from the weir and is observed twice daily. The discharge is calculated by the Francis formula. In extreme freshets, the discharge is observed at a masonry intake dam a short distance downstream. The drainage basin of Starch Factory Creek includes Graefenberg Creek and reservoir, as elsewhere described. Graefenberg reservoir has a capacity of 30,000,000 gallons, and water is diverted therefrom through a 12-inch conduit.

The region tributary to Starch Factory Creek consists of cleared farm land, chiefly sodded slopes rising from the stream to the divide on either side, a height of 300 to 400 feet, in a distance of about 1 mile from the main stream. A limited number of lateral tributaries drain the more remote portions of the area. The stream is tributary to Mohawk River near Utica, N. Y. The drainage basin is shown on the Utica sheet of the United States Geological Survey Topographic Atlas, from which the drainage areas have been taken.

The observations at this station during 1904 have been made under the direction of R. E. Horton, district hydrographer.

Drainage areas of Starch Factory Creek.

	Sq. miles.
Above Graefenberg reservoir dam [a]	0.45
Above gaging weir	3.40
Above Savage reservoir dam	3.81
Above mouth	6.60

[a] Topographic area above Graefenberg reservoir dam. The yield is developed from this area by tiling from springs.

Mean daily discharge, in second-feet, of Starch Factory Creek near New Hartford, N. Y., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.59	1.00	1.22	a87.00	5.24	1.34	2.02	1.63	0.61	0.71	1.18	1.02
2	1.47	1.00	1.28	b43.75	3.31	1.18	1.34	4.76	.56	.66	1.08	.81
3	1.47	.90	8.00	b15.35	2.28	1.18	1.21	1.45	.48	.56	1.02	.61
4	1.47	.79	25.12	b8.10	2.15	5.92	1.12	1.18	.65	.56	.96	.56
5	1.47	.79	3.20	b7.05	2.02	2.28	1.75	.93	.56	.56	.96	.56
6	1.41	1.28	2.22	b21.16	1.81	1.94	1.51	1.06	.48	.66	.96	.61
7	1.34	69.88	8.03	b27.50	1.69	1.21	1.18	.80	.48	.71	.96	.61
8	1.34	33.00	48.45	b15.60	1.63	1.18	1.06	.74	.48	.56	.91	.61
9	1.34	14.00	9.70	b28.00	1.57	14.09	.87	.74	.48	.61	.86	.61
10	1.22	13.50	5.33	21.80	1.45	6.12	1.63	.74	.48	1.62	.91	.61
11	1.22	10.80	3.99	16.80	1.45	2.98	2.15	.74	.48	2.67	.86	.56
12	1.34	7.89	3.29	17.70	1.34	1.75	2.98	.74	.48	1.49	.86	.56
13	1.22	4.94	2.40	7.50	1.15	1.21	2.02	.74	.48	1.08	.86	.56
14	1.22	4.00	2.03	4.80	1.12	1.18	1.21	.93	.48	.96	.86	.56
15	1.22	2.03	1.90	5.00	10.83	1.27	1.12	.68	1.81	.86	.81	.56
16	1.22	1.53	1.90	4.70	5.54	2.10	1.00	.68	.81	.86	.86	.56
17	1.22	1.72	1.90	8.22	2.82	1.45	1.00	.62	.56	.66	.71	.56
18	1.10	1.34	1.78	9.20	1.94	1.27	2.10	.68	.56	.66	.61	.66
19	1.05	1.28	3.73	5.82	1.75	1.21	1.06	.59	.61	.66	.61	.66
20	1.00	1.16	4.27	4.40	2.42	1.12	.87	12.24	.61	.66	.86	.66
21	.95	1.34	2.88	3.65	2.28	1.18	.87	2.58	.61	31.38	1.19	.66
22	1.10	3.73	6.86	6.32	1.69	1.18	.80	14.72	.56	4.97	1.08	.71
23	2.09	2.22	b62.00	13.70	1.33	1.18	8.70	4.01	.56	2.90	.96	1.36
24	1.90	1.72	b46.00	7.48	1.94	1.18	1.51	2.02	1.02	1.95	.91	7.36
25	1.59	1.41	250.00	9.54	1.33	1.00	1.06	1.45	1.13	1.68	1.02	2.08
26	1.34	1.41	a221.50	5.34	2.98	2.10	6.32	(c)	1.53	1.81	.96	1.31
27	1.22	1.16	a40.00	10.24	2.74	2.10	1.88	(c)	.86	2.08	.91	21.90
28	1.10	1.16	a19.50	16.45	1.57	2.10	2.74	(c)	.66	1.74	.86	26.20
29	1.05	1.22	a17.50	7.58	1.27	1.45	6.02	(c)	1.81	1.68	.86	6.84
30	1.00	.....	a21.00	6.90	1.39	1.57	1.94	(c)	1.36	1.55	.96	3.96
31	1.00	.....	a26.00	.....	1.69	.....	1.39	(c)	.....	1.24	.....	3.46

a 50-foot spillway. b Approximate. c Repairing weir.

Estimated monthly discharge of Starch Factory Creek near New Hartford, N. Y., for 1904.

[Drainage area, 3.40 square miles.]

Month.	Discharge in second-feet.			Corrected mean.[a]	Run-off.		Rainfall.
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.	Inches.
January	2.09	0.95	1.30	2.07	0.609	0.702	1.69
February	69.88	.79	6.49	7.26	2.14	2.31	1.79
March	250.00	1.22	27.51	28.27	8.45	9.74	2.91
April	87.00	3.65	14.89	15.67	4.61	5.14	3.53
May	10.83	1.12	2.38	3.15	.926	1.07	3.61
June	14.09	1.12	2.23	3.00	.882	.984	4.82
July	6.32	.80	2.01	2.78	.818	.943	6.94
August 1–25	14.72	.59	2.30	3.07	.903	.840	4.34
September	1.81	.48	.74	1.51	.444	.496	2.79
October	31.38	.56	2.28	3.05	.897	1.03	3.11
November	1.19	.61	.91	1.68	.494	.551	.60
December	26.20	.56	2.85	3.62	1.06	1.22	2.80

[a] Including diversion to Graefenberg reservoir.

SYLVAN GLEN CREEK NEAR NEW HARTFORD, N. Y.

New Hartford, or Sylvan Glen, Creek is the inflowing stream tributary to reservoir No. 4 of the Utica waterworks. The stream consists of two main branches, the larger flowing in a deep-cut wooded shale valley, the smaller draining a shallow ravine and a marshy divide. The flow of this stream became very small in May, 1900, and it may become dry at times. The weir, which is located at the mouth of the stream, was erected in January, 1904, by the Consolidated Water Company, of Utica, N. Y., by whom the record is furnished. The gage is placed 6 feet upstream and is read twice daily. The weir has a central low-water notch 2 inches deep and 2 feet long, and a main crest 8 feet long with two end contractions. The drainage basin, which lies at an elevation of from 700 to 1,500 feet above tide, is shown on the Utica and Oriskany sheets of the United States Geological Survey Topographic Atlas. It comprises chiefly woodland and pasture with some tillage, 1.18 square miles in extent.

The observations at this station during 1904 have been made under the direction of R. E. Horton, district hydrographer.

Mean daily discharge, in second-feet, of Sylvan Glen Creek at New Hartford, N. Y., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	0.15	0.20	11.65	1.38	0.31	0.26	0.64	0.10	0.16	0.34	0.20
2	.....	.15	.21	4.21	.88	.23	.64	.60	.10	.13	.31	.15
3	.....	.15	1.17	1.83	.77	.23	.31	.47	.13	.12	.31	.10
4	.....	.14	2.27	1.90	.60	3.29	.12	.26	.12	.12	.29	.09
5	.....	.14	.42	2.27	.49	.55	.55	.19	.09	.11	.29	.12
6	.....	.15	.29	1.90	.41	.73	.36	.27	.09	.12	.26	.12
7	0.22	3.23	1.51	6.65	.38	.34	.17	.20	.08	.11	.25	.13
8	.22	9.61	9.53	4.06	.31	.27	.12	.16	.10	.09	.25	.13
9	.22	4.41	3.19	5.41	.27	6.15	.09	.13	.10	.11	.23	.12
10	.22	1.61	.96	4.80	.23	1.75	.29	.15	.09	.40	.23	.12
11	.22	.62	.62	3.75	.19	.73	13.94	.16	.08	.73	.20	.10
12	.20	.36	.39	3.85	.17	.47	5.16	.13	.08	.45	.21	.10
13	.21	.27	.32	1.68	.16	.32	1.31	.13	.07	.34	.20	.12
14	.20	.27	.27	1.15	.13	.25	.49	.17	.09	.26	.23	.11
15	.20	.25	.25	1.09	3.56	7.90	.32	.12	.41	.21	.21	.12
16	.20	.21	.22	1.38	1.15	1.09	5.16	.08	.15	.20	.21	.12
17	.20	.18	.22	3.65	.60	.47	.17	.08	.10	.16	.17	.12
18	.15	.15	.22	3.26	.36	.32	.47	.10	.08	.13	.13	.12
19	.15	.12	.24	1.98	.41	.25	.19	.09	.10	.12	.16	.13
20	.14	.11	.62	1.20	1.26	.17	.11	4.06	.13	.11	.23	.15
21	.14	.10	.37	1.90	.60	.21	.10	.99	.11	16.01	.27	.15
22	.15	.42	1.26	1.38	.40	.32	.10	4.06	.09	1.46	.23	.15
23	.44	.29	15.12	1.09	.25	.19	3.75	1.53	.08	.82	.21	.47
24	.32	.26	9.23	.93	.27	.13	.64	.51	.36	.64	.19	2.30
25	.26	.21	39.61	1.09	.21	.11	.38	.36	.34	.55	.27	.60
26	.22	.20	27.59	.93	1.46	.09	3.85	.26	.38	.64	.21	.32
27	.22	.15	2.72	1.46	1.15	.07	.77	.19	.26	.73	.16	22.07
28	.20	.15	1.10	3.96	.43	.07	.99	.15	.17	.60	.16	8.16
29	.15	.22	1.10	1.98	.32	.13	2.21	.12	.38	.43	.15	2.70
30	.15	.....	2.56	1.75	.68	.38	.73	.11	.36	.38	.10	1.46
31	.15	.....	1.68	.....	.49	.....	.47	.10	.....	.36	.....	1.20

Estimated monthly discharge of Sylvan Glen Creek near New Hartford, N. Y., for 1904.

[Drainage area, 1.18 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January 7–31	0.44	0.14	[a]0.21	0.178	0.205
February	9.61	.10	.84	.712	.768
March	39.61	.20	4.05	3.43	3.95
April	11.65	.93	2.80	2.37	2.64
May	3.56	.13	.64	.542	.625
June	7.90	.07	.92	.780	.870
July	13.94	.09	1.43	1.21	1.40
August	4.06	.08	.53	.449	.518
September	.41	.07	.16	.136	.152
October	16.01	.09	.86	.729	.841
November	.34	.10	.22	.186	.208
December	22.07	.09	1.35	1.14	1.31
The year	.....	.....	1.17	.988	13.49

[a] Mean for 25 days taken as mean for entire month.

GRAEFENBERG CREEK NEAR NEW HARTFORD, N. Y.

A gaging weir was erected above the inflow to Graefenberg reservoir, June 7, 1903, and a standard rain gage was placed on the adjoining meadow slope some distance from trees and structures. This small catchment basin, having a topographic area, 0.282 square mile in extent, is cleared farm land, chiefly meadow and pasture.[a] It lies between elevations 1,100 and 1,300 feet above tide, and near the summit of the general plateau south of Mohawk River. The soil is porous and the stream is fed largely from the ground water reserve.[b] The weir is compound in form, 5 feet crest length with two end contractions and a central notch 2 feet long .21 foot deeper.

The discharge is calculated by the Francis formula. The gages are read by R. O. Salisbury, and the record furnished by the Consolidated Water Company of Utica, N. Y.

[a] Yield from this area developed by tiling from springs in surrounding slopes.

[b] Other nearby stream channels have tributary areas of equal or larger extent run dry in summer.

Precipitation, in inches, at Graefenberg reservoir, near New Hartford, N. Y., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.01	.....	0.36	0.34	.....	0.03	0.745	0.15	T.	T.	.....	.....
2	T.	T.	.....	.35	.....	.....	.19	.02	T.	0.02	T.	.....
3	.41	0.04	T.	.50	.....	T.	.195	.17	T.	.03	.....	.....
4	.04	.03	.10	.....	.....	.....	.....	.....	0.19	.....	.....	0.04
5	.....	.01	.....	.....	.....	.90	.09	.....	.....	.....	T.	T.
6	T.	.31	.....	.....	.....	.225	.39	.135	.....	.18	0.04	.04
7	.....	T.	T.	.....	.....	.01	T.	.....	.....	T.	T.	T.
8	.....	.57	.73	.....	.....	.....	T.	.....	.....	.....	.....	.02
9	.05	T.	T.	.03	T.	1.18	.....	T.	.02	.04	.....	.03
10	.09	.....	.04	.23	T.	.29	.31	.....	T.	.22	.....	.....
11	.01	.....	.....	.17	.....	.....	.365	.08	.....	.31	.....	.....
12	(a)	.....	.....	.24	.....	.....	1.08	.04	.....	.04	.....	.....
13	.....	.....	T.	.05	.....	.....	.19	.01	T.	.13	.03	.05
14	.....	T.	T.	T.	.....	.....	.....	.23	.....	.....	.....	T.
15	.....	.....	.12	.03	0.78	.13	.....	.....	.76	.....	.....	T.
16	.....	.10	.02	.52	.75	.81	.015	.....	.01	.....	.....	.....
17	.....	.01	.....	.....	.....	.....	.....	.....	.....	.....	.....	T.
18	.....	.....	.08	.....	.....	.....	.41	.13	.....	.....	.....	.02
19	.....	.....	.21	.....	T.	.....	.....	.....	.02	.....	.....	.02
20	.....	.03	T.	.06	.34	.....	.....	1.19	.....	.....	.....	.02
21	.....	.....	T.	.02	.80	.14	.005	.....	.19	.76	.10	.12
22	.....	T.	.08	.....	T.	.01	.....	.....	T.	.70	.....	T.
23	.....	.05	.....	.....	T.	.17	.745	1.04	.....	T.	.....	.05
24	.....	.11	.....	.....	.24	.....	.30	.....	.25	T.	.....	.14
25	.....	.03	.....	.11	.....	T.	T.	.....	.24	T.	.16	.....
26	.....	T.	.....	.005	.32	.....	.615	.01	T.	.08	.02	.01
27	.09	.....	.18	.02	.23	.....	.065	.....	.26	.11	T.	.60
28	.....	.....	.14	.69	.10	.....	.26	.....	.....	T.	.09	1.33
29	.....	.20	.....	.07	.....	.38	.77	.....	T.	.....	.03	.07
30	.01	.....	.....	.07	.....	.01	.....	.....	.36	.....	.....	.....
31	.....	.....	.....	.....	.35	.....	.....	.....	.....	.....	.....	.....
Total	.71	1.49	2.06	3.505	3.91	4.28	6.74	3.20	2.30	2.62	.47	2.56

a No record January 12–25, 1904.

Precipitation, in inches, at Savage reservoir, near Utica, N. Y., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	0.96	0.29	0.07	0.02	0.53	0.35	.....	.....	.....	.....
2	.....	0.05	.....	.52	.....	.....	.23	.03	.....	0.07	.....	.....
3	0.42	.07	.....	.09	.....	.....	.....	.78	.....	.03	.....	.....
4	.06	.24	.11	.....	.....	.72	.01	.....	0.35	.....	.....	.....
5	.....	.....	.....	.....	.....	.07	.70	.....	.03	.....	0.06	.....
6	.....	.....	.....	.....	.....	.23	.....	.39	.....	.21	.....	0.08
7	.....	.76	.64	.27	.....	.05	.....	.....	.....	.....	.....	.....
8	.06	.10	.....	.....	.....	.07	.....	.....	.....	.....	.....	.05
9	.10	.09	.....	.10	.....	1.42	.....	.....	.07	.07	.....	.07
10	.....	.03	.....	.23	.....	.31	.43	.....	.....	.26	.....	.....
11	.....	.....	.11	.21	.....	.....	.21	.09	.....	.41	.....	.....
12	.....	.....	.....	.16	.....	.....	1.02	.04	.....	.05	.....	.....
13	.....	.....	.....	.13	.....	.....	.36	.01	.....	.16	.....	.14
14	.34	.....	.....	.....	.....	.....	.....	.34	.....	.....	.11	.04
15	.....	.09	.19	.07	1.54	1.04	.01	.....	.84	.....	.....	.....
16	.20	.04	.06	.37	.12	.03	.....	.....	.06	.....	.....	.....
17	.....	.13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
18	.....	.....	.38	.....	.....	.....	.45	.27	.....	.....	.....	.06
19	.10	.....	.....	.....	.10	.....	.....	.....	.16	.....	.....	.04
20	.18	.....	.....	.....	.31	.....	.....	1.37	.....	.....	.....	.06
21	.....	.....	.....	.19	.19	.10	.02	.76	.21	1.10	.09	.17
22	.99	.10	.07	.....	.....	.26	.....	.....	.....	.95	.....	.....
23	.....	.18	.61	.....	.06	.....	1.14	1.04	.....	.02	.....	.08
24	.....	.17	.....	.14	.33	.....	.01	.....	.46	.03	.....	.17
25	.07	.04	.05	.....	.02	.....	.....	.....	.35	.....	.21	.....
26	.....	.....	.23	.....	.61	.....	.71	.02	.....	.10	.03	.....
27	.05	.....	.....	.09	.26	.....	.14	.....	.32	.15	.06	.60
28	.....	.....	.....	.61	.....	.02	.25	.....	.....	.....	.12	1.32
29	.11	.....	.....	.....	.42	.40	.92	.....	.....	.....	.05	.09
30	.....	.....	.....	.12	.....	.63	.....	.....	.43	.....	.....	.06
31	.....	.....	.35	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total	2.68	2.09	3.76	3.59	4.03	5.37	7.14	5.49	3.28	3.61	.73	3.03

REELS CREEK AND JOHNSTON BROOK NEAR DEERFIELD, N. Y.

A gaging record at the waterworks intake dam on Reels Creek was begun January 1, 1901.[a] In order to secure a more accurate record during periods of diversion, a weir was constructed on the shale rock stream bed just above the intake dam in 1903. A second weir was constructed on Johnston Brook, a tributary of Reels Creek, which enters below the point of gaging the latter. The calculated flow and the precipitation observed from a standard rain gage at Deerfield reservoir are given below.

The drainage of Reels Creek lies on the north slope of Mohawk River, to which the stream is tributary. The tributaries are numerous and the valleys deep cut with gravel or sodded slopes favoring rapid discharge of storm waters.

Johnston Brook flows in a deep valley whose tributaries are, lying

[a] See Water-Supply Paper No. 82, p. 82, and Water-Supply Paper No. 97, p. 209; see also Report on Stream Gaugings, contained in Supplement, Report of State Engineer and Surveyor, New York, for 1902, pp. 136-141, also 1903, pp. 94-98.

mostly to the north of the stream, drained by short parallel feeders that head well below the divide and are supplied to some extent from ground storage.

The observations at this station during 1904 have been made under the direction of R. E. Horton, district hydrographer.

Drainage areas of Reels Creek.[a]

Location.	Square miles.	
	Place to place.	Total.
Reels Creek above weir	4.42	4.42
Reels Creek above Johnston Brook	.05	4.47
Johnston Brook above weir	.78	.78
Johnston Brook above mouth	.01	.79
Reels Creek including Johnston Brook	.79	5.26
Reels Creek above mouth	4.14	9.4

[a] From the Utica sheet of the United States Geological Survey Topographic Atlas.

Mean daily discharge, in second-feet, of Reels Creek near Deerfield, N. Y., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.68	3.52	2.49	30.50	23.50	.....	0.54	0.17	0.17	1.70	2.98	0.88
2	2.42	3.21	2.75	44.80	6.80	.....	1.91	.79	.17	.54	2.78	.74
3	2.23	2.90	4.21	30.50	3.40	.....	1.10	.24	.17	.31	2.18	.50
4	2.23	2.68	19.62	30.50	2.40	.....	.50	.17	.45	.31	2.04	.50
5	2.23	2.49	28.50	30.50	2.40	17.80	1.10	.28	.21	.31	2.04	.45
6	2.16	2.98	61.85	32.80	2.40	33.90	1.38	.17	.17	1.38	1.91	.45
7	2.10	13.41	99.20	82.00	2.40	6.00	.74	.17	.17	1.04	1.50	.45
8	2.10	9.75	65.00	50.10	2.40	3.40	.34	.17	.17	1.04	1.38	.45
9	2.10	.....	9.10	44.80	1.80	38.70	.31	.17	.17	1.04	1.32	.45
10	2.10	.....	8.35	49.10	1.80	10.50	1.10	.17	.17	1.38	1.27	.45
11	2.10	8.94	9.00	76.00	1.80	9.00	.64	.17	.17	1.77	1.22	.45
12	2.10	7.70	9.00	115.20	1.80	.....	.74	.17	.17	3.58	1.16	.45
13	2.10	6.17	9.00	30.50	1.80	.....	.54	.17	.17	3.82	1.16	.45
14	2.10	4.57	9.00	45.10	1.80	.....	.31	.17	.17	3.42	1.16	.45
15	2.10	3.52	10.50	18.00	30.50	.....	.21	.17	.17	3.25	1.16	.45
16	2.10	2.75	7.70	15.30	23.50	.....	.17	.17	.17	2.78	1.16	.45
17	2.10	2.49	7.92	14.00	9.00	.....	.17	.17	.17	2.26	1.16	.45
18	2.10	2.49	7.81	18.70	2.90	.....	.79	.17	.17	2.04	1.16	.45
19	2.10	2.49	8.04	13.60	2.40	.....	.31	.17	1.50	1.50	1.16	.45
20	2.10	2.49	10.14	8.30	12.00	30.50	.21	.....	2.41	1.27	1.91	.45
21	2.10	2.49	9.64	9.00	5.20	144.10	.17	6.74	1.70	.....	1.77	.45
22	5.92	2.49	8.72	10.50	2.40	99.40	.17	3.01	.45	11.78	1.44	.45
23	17.80	3.06	24.31	13.60	2.40	.....	7.26	7.26	.17	7.16	1.32	1.04
24	8.04	2.90	19.43	10.50	6.80	.45	2.93	2.11	1.10	5.08	1.27	.....
25	5.65	2.55	92.80	12.00	8.30	.38	1.27	.79	2.48	3.74	1.38	.....
26	4.04	2.49	197.00	14.40	22.50	.31	9.22	.24	1.10	4.00	.98	1.91
27	4.04	2.49	175.50	24.50	27.50	.31	1.70	.17	.54	3.82	.79	.....
28	4.04	2.75	49.90	30.50	7.70	.31	.93	.17	.24	3.74	.74	.....
29	3.69	2.62	33.60	19.50	2.90	2.78	1.32	.17	3.92	3.74	.74	.....
30	3.52	.....	30.50	29.50	8.30	1.50	.64	.17	4.36	3.74	.93	.....
31	3.21	.....	35.20	.....	7.70	.....	.31	.17	.....	3.42	.....	.....

Estimated monthly discharge of Reels Creek near Deerfield, N. Y., for 1904.

[Drainage area, 4.5 square miles.]

Month.	Discharge in second-feet.			Run-off.		Rainfall.
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.	Inches.
January	17.80	2.10	3.40	0.756	0.872	4.62
February, 27 days	13.41	2.49	4.01	.891	.895	3.85
March	197.00	2.49	34.38	7.64	8.81	2.97
April	115.20	8.30	31.81	7.07	7.89	2.64
May	30.50	1.80	7.69	1.71	1.97	4.17
June, 17 days	14.41	.31	23.49	5.22	3.30	6.16
July	9.22	.17	1.26	.280	.323	4.63
August, 30 days	7.26	.17	.83	.184	.205	4.87
September	4.36	.17	.78	.173	.193	4.51
October, 30 days	11.78	.31	2.83	.629	.702	3.87
November	2.93	.74	1.44	.320	.357	.27
December, 24 days	1.91	.45	.57	.127	.113	3.36

Mean daily discharge, in second-feet, of Johnston Brook near Deerfield, N. Y., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.45	0.50	0.87	8.00	3.22	1.00	0.34	0.18	0.18	0.40	0.87	0.21
2	.45	.50	.87	6.06	1.68	.40	1.00	.18	.18	.18	.34	.12
3	.45	.50	1.68	4.42	1.00	.37	.28	.40	.26	.18	.30	.12
4	.45	.50	1.46	2.92	.74	.37	.18	.18	.22	.18	.30	.12
5	.45	.50	1.36	2.71	.64	3.69	.74	.18	.18	.18	.30	.12
6	.45	.64	6.68	4.79	.47	4.02	.57	.30	.18	.24	.28	.12
7	.45	7.12	8.00	12.64	.47	.52	.24	.18	.18	.18	.24	.12
8	.45	2.81	2.84	6.06	.44	.37	.18	.18	.18	.18	.24	.12
9	.45	1.93	1.46	4.42	.42	(a)	.18	.18	.18	.18	.22	.12
10	.45	1.56	1.36	(b)	.40	.92	1.15	.18	.18	1.74	.18	.12
11	.45	1.46	1.36	10.50	.37	.57	.26	.18	.18	2.24	.18	.12
12	.45	1.05	1.36	10.85	.37	.42	.42	.18	.18	2.44	.18	.12
13	.45	.57	1.36	4.70	.37	.37	.26	.18	.18	1.56	.18	.12
14	.50	.52	1.36	3.38	.37	.64	.18	.18	.18	.74	.18	.12
15	.50	.50	1.30	1.68	4.61	1.20	.18	.18	.52	.78	.18	.12
16	.50	.50	1.30	1.68	2.71	.57	.18	.18	.18	.37	.18	.12
17	.50	.50	1.36	2.06	.92	.37	.18	.18	.18	.32	.18	.12
18	.50	.50	1.46	2.84	.69	.37	1.31	.18	.18	.30	.18	.12
19	.50	.50	1.46	1.62	.37	.37	.21	.18	1.87	.30	.18	.12
20	.50	.50	1.87	1.31	2.64	.37	.18	(a)	1.31	.26	.26	.12
21	.50	.50	1.87	1.56	1.10	1.51	.18	4.02	.30	10.28	.25	.12
22	1.05	.50	2.31	1.46	.42	1.51	.18	1.62	.18	2.71	.21	.12
23	4.10	.78	10.86	1.25	.37	.47	3.46	1.93	.18	1.31	.21	.24
24	1.40	.87	3.76	1.15	1.00	.19	.57	.37	.92	.57	.21	2.06
25	.60	.60	(a)	1.41	1.10	.18	.18	.21	1.93	.47	.25	.78
26	.55	.50	(a)	1.31	8.61	.18	2.51	.18	1.31	.57	.24	.30
27	.55	.50	(a)	1.99	2.71	.18	.32	.18	.26	.57	.18	.82
28	.55	.78	(a)	7.67	.42	.18	.22	.18	.18	.57	.18	7.45
29	.55	.92	2.58	3.38	.37	3.07	.18	.18	(a)	.57	.18	2.44
30	.55	.....	3.30	1.87	.82	.50	.18	.18	1.87	.57	.21	1.31
31	.55	.....	2.18	.....	.92	.....	.18	.18	.....	.50	.....	.54

a Discharge exceeds capacity of weir; record not available.
b Repairing weir; record not available.

Estimated monthly discharge of Johnston Brook near Deerfield, N. Y., for 1904.

[Drainage area, 0.79 square mile.]

Month.	Discharge in second-feet.			Run-off.		Rainfall.
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.	Inches.
January	4.10	0.45	0.65	0.823	0.949	4.62
February	7.12	.50	.99	1.25	1.34	3.85
March, 27 days	(a)	.87	2.50	3.16	3.17	2.97
April, 29 days	12.64	1.15	4.06	5.14	5.54	2.64
May	4.61	.37	1.15	1.46	1.68	4.19
June, 29 days	(a)	.18	.86	1.09	1.18	6.16
July	3.46	.18	.53	.671	.774	4.63
August, 30 days	(a)	.18	.43	.544	.607	4.87
September, 29 days	(a)	.18	.48	.608	.656	4.51
October	10.28	.18	1.02	1.29	1.49	3.87
November	.37	.13	.22	.278	.310	.27
December	7.45	.12	.60	7.59	.875	3.36

a Discharge exceeds capacity of weir; record not available.

Precipitation, in inches, at Deerfield reservoir, near Deerfield, N. Y., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		0.02							0.30			
2	0.65	.12					0.75	0.57		0.05		
3			0.60						.32			
4		.06				0.52						0.10
5		.04				.52	.65	.17		.30		
6		.74		0.45								
7		.94	.44									.05
8	.25					2.03			.25			.10
9			.05	.35		.25						
10							.12	.08		.70		
11				.32						.40		
12				.08			.25			.30		
13				.12				.12				.13
14	1.08		.04			.39						
15		.05		.25	1.49	.38			.32			
16	.22				.08							
17												
18			.22	.25			.77		.82			.10
19		.03							.78			.13
20	.02				.68	.51		2.00			0.05	.20
21	.88				.32			1.25		1.75		
22	1.20	.24	.72			.92		.65				
23		.40			.48		1.08					
24		.16							.48			
25					.23					.17	.22	
26	.32		.45		.40		.65	.03	.32	.20		
27				.40								
28		.45		.20			.36					2.10
29		.60		.10		.52			.92			
30				.12	.41	.12						.45
31			.45		.08							
Total	4.62	3.85	2.97	2.64	4.17	6.16	4.63	4.87	4.51	3.87	.27	3.36

NAIL CREEK AT UTICA, N. Y.

The record of the flow of this stream, obtained at a weir at the foot of the water-supply pond of the Globe Woolen Mill, Utica, N. Y., has been furnished by William S. Bacot, civil engineer. The weir consists of eight notches, each 1 foot in length and 1 foot in depth, cut in ¼-inch steel plates attached to the upstream side of the waste gates of the pond mentioned. The depth of overflow is observed on a vertical enameled iron gage, divided to feet and hundredths, located 9 feet upstream from the weir. Outflow takes place from a still pond. The waste gates to which the weir is attached are practically water-tight. The very slight leakage occurring has been estimated and allowed for, together with water diverted for use in the adjoining mills. Four of the weir notches are placed 2 inches below the remaining four notches. The lower notches take the entire ordinary flow of the stream. The pond above the weir has an area of 1.4 acres, and a slight error may be introduced in the results on windy days by water slopping over the crests of the higher notches.

The effective drainage area at the weir is less than the natural drainage area, owing to diversion to the combined sewer system of the city in the lower portion of the watershed. The drainage area is nearly all heavily sodded land, comprising suburban plats and pasturage. It contains possibly 5 per cent of cultivated area and an equal percentage of hard earth roads and pavements. Perhaps 10 per cent is sparsely timber covered. The entire area is underlaid with slate shale, usually at a depth of from 2 to 5 feet below surface, and the soil is heavy clay, with occasional gravel and loam. The basin comprises an upper and a lower plateau; the main tributaries rise in the steep side slopes of the upper plateau, which are often deeply serrated, forming gulfs from which springs issue, excepting in unusual droughts. The lower plateau is more or less swampy near the margin of the hills. The upper plateau contains a large cemetery, in which are numerous artificial drains, also a number of small ponds. The drainage areas are shown on the Oriskany and Utica sheets of the United States Geological Survey Topographic Atlas. The drainage from the plateau is received on the north in an artificial ditch following the highway and which separates the area tributary to the stream from the urban district. Below the junction of the main branches, the stream flows in the abandoned channel of the Chenango canal, in which one branch of the stream flows from its source. In unusual freshets the artificial channel carrying the north branch of the stream underneath the street for a distance of about 1,000 feet is of insufficient capacity, and the overflow passes directly into the city sewers and is diverted from its natural course.

Drainage areas of Nail Creek.[a]

	Sq. miles.
Natural area above Globe Woolen Mill	4.32
Effective area prior to August 31, 1904	3.66
Effective area after August 31, 1904	3.49
Upland area above 600 contour	1.40

Mean daily discharge, in second-feet, of Nail Creek at Utica, N. Y., for 1904.

Day.	June.	July.	Aug.	Sept.	Oct.	Day.	June	July.	Aug.	Sept.	Oct.
1		1.61	1.81	0.60	1.07	17				0.69	
2		2.25	1.55	.81		18		1.32	0.69		
3					1.10	19		1.14	.99	.88	
4				.75	1.03	20		1.14	1.81	.81	
5		1.74			1.10	21		1.14		.84	
6		1.68				22		1.14	1.68	.81	
7		1.32		.92		23		5.54	4.19	.88	
8		1.49		.88		24			2.17	1.03	
9		1.28		.88		25		1.18	1.74		
10				.92		26		4.29	1.61	.88	
11		1.68		.92		27	1.32	2.40	1.44	1.07	
12		3.52		1.10		28	1.72	1.61		1.10	
13		3.15		.78		29	1.61	4.39	.84	1.10	
14		1.88		.81		30	1.32	1.95		1.95	
15		2.02	1.10	1.68		31					
16		1.32	1.14	.81							

Estimated monthly discharge of Nail Creek at Utica, N. Y., for 1904.

[Drainage area preceding August 31, 1904, 3.66; succeeding August 31, 1904, 3.49 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.[a]	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
June, 4 days			1.49	0.407	0.061
July, 25 days			2.09	.571	.531
August, 14 days			1.63	.445	.232
September, 25 days			.96	.276	.257
October, 4 days			1.08	.309	.046

[a] Part of maximum flow diverted.

WEST CANADA CREEK AT TWIN ROCK BRIDGE, N. Y.

A current-meter gaging station was established at Twin Rock Bridge, September 7, 1900, by R. E. Horton. A gage board, divided decimally, is attached to the upstream side of the right-hand abutment, the coping of the abutment over the gage being used as a bench mark.

[a] From the Utica sheet of the United States Geological Survey Topographic Atlas.

The bridge is 167.5 feet long between abutments, and consists of two spans. The bed is of gravel and cobble, and the entire flow passes underneath at all stages. In the winter the stream becomes completely ice covered, requiring special discharge measurements. The gage is read twice each day by George Rood, and the record is furnished by the Utica Gas and Electric Company. The drainage area is shown on the Utica, Little Falls, Remsen, Wilmurt, Old Forge, and Canada Lakes sheets of the United States Geological Survey Topographic Atlas. There are about fifty small lakes and a few undrained ponds in the watershed of the stream. Most of these are situated near the headwaters and above the gaging station, the largest single water surface being Honnedaga Lake, 1.4 square miles in extent. There is also a small amount of controllable storage in reservoirs formed by three dams. Swamps and marshes are numerous in the region of the headwaters, usually adjoining lakes and tributaries and having an extent of one-half square mile or less each. Much of the region above the gaging station is timber covered. There are extensive sand areas in the central and upper drainage basins. The soil of the upper watershed is underlaid by granitic gneiss usually at or near the surface, excepting in alluvial valleys. From a point just above Twin Rock Bridge and extending downstream beyond Trenton Falls the underlying geological formation is Trenton limestone.[a]

Compacted snow accumulates in the woodlands in winter, often to a depth of 3 or 4 feet, and representing an inch of water for each 5 or 6 inches of snow. This melts slowly, feeding the stream in March and April, which months may show a run-off greatly exceeding the precipitation. The drainage area above Twin Rock Bridge is 364 square miles; above Trenton Falls, 375 square miles. During the present season a Frieze self-recording gage has been erected at Trenton Falls dam. Tests by weir to determine the discharging capacity of the turbines, which are a special Swiss design, have been made by the power company.

The observations at this station during 1904 have been made under the direction of R. E. Horton, district hydrographer.

[a] For geological description of Trenton Falls see paper by C. S. Prosser and E. R. Cumings in Report of New York State Museum, 1895, pp. 619–628.

Discharge measurements of West Canada Creek at Twin Rock Bridge, N. Y., in 1904.

Date.	Hydrographer.	Area.	Mean velocity.	Gage height.	Discharge.
		Sq. feet.	*Feet per sec.*	*Feet.*	*Second-feet.*
June 3	C. A. Swancott	547	0.85	2.18	463
August 4	do	404	.75	1.30	304
August 30	do	394	.67	1.45	[a] 265
September 19	Horton and Evans	580	1.03	2.48	[b] 597
October 8	A. M. Evans	575	1.26	2.33	728
October 15	do	645	1.77	2.83	1,142
November 21	Weeks and Swancott	455	.86	1.63	394

[a] Log jam at center pier. [b] Log jam below section.

Mean daily gage height, in feet, of West Canada Creek at Twin Rock Bridge, N. Y., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.40	2.20	2.60	3.82	7.70	2.35	3.40	2.30	1.00	6.15	2.10	1.35
2	3.50	2.10	2.68	4.48	8.95	2.45	3.85	2.00	1.10	3.50	2.40	1.35
3	2.00	2.10	2.80	4.45	8.55	2.22	3.70	1.60	1.55	3.45	2.25	1.30
4	2.00	2.05	2.88	3.68	8.40	2.00	3.15	1.20	4.00	2.05	2.30	1.30
5	2.00	2.12	3.50	3.52	8.60	3.45	3.45	1.00	3.60	2.25	2.20	1.20
6	2.00	2.00	3.50	3.48	8.80	3.15	4.35	4.15	3.10	2.45	1.90	1.20
7	2.05	2.15	3.45	3.30	8.35	3.00	3.55	2.90	2.55	2.40	1.78	1.15
8	.....	3.20	4.35	4.50	8.20	4.40	2.05	2.55	2.15	2.30	1.72	1.15
9	2.20	3.80	5.15	7.00	7.20	5.90	2.10	3.10	2.10	2.22	1.80	1.10
10	2.30	2.00	4.85	9.00	6.10	8.45	2.00	1.70	2.00	3.50	1.85	1.70
11	2.30	3.90	4.45	7.42	4.45	4.45	1.20	1.45	2.15	7.10	1.70	1.48
12	1.09	3.60	4.25	5.70	3.40	3.40	1.20	1.45	2.10	7.00	1.60	2.10
13	1.07	3.30	3.75	4.88	3.50	3.00	1.50	1.40	3.05	5.40	1.55	2.35
14	2.00	3.20	3.50	4.35	3.25	2.25	1.50	1.45	3.45	3.20	1.42	.90
15	1.90	2.95	3.30	3.52	2.60	2.20	1.20	1.55	3.55	2.50	1.45	1.05
16	1.80	2.85	3.00	2.85	6.00	2.35	1.50	.80	3.65	2.35	1.60	1.00
17	2.05	2.65	2.82	2.80	5.80	2.25	1.50	.80	2.50	2.40	1.60	1.00
18	2.02	2.50	2.80	2.95	5.00	2.12	1.40	1.20	2.20	2.85	1.60	1.55
19	2.18	2.38	2.75	2.75	4.00	2.00	1.30	1.10	2.40	2.20	1.60	1.00
20	2.30	2.40	2.88	2.62	4.25	1.90	1.25	6.50	3.00	2.10	1.60	1.00
21	2.32	2.40	2.80	2.45	5.55	1.95	1.00	9.50	4.25	3.35	1.68	1.10
22	2.40	2.68	2.85	2.60	4.30	2.12	1.00	7.50	3.40	5.85	1.68	1.10
23	2.40	3.40	3.25	3.00	4.18	2.95	.90	6.45	2.75	4.45	1.60	1.20
24	2.50	3.58	4.20	3.95	3.15	2.50	.95	5.05	3.30	3.55	1.72	1.30
25	2.75	3.35	4.95	7.50	3.55	2.15	1.20	3.05	6.75	3.15	1.30	2.00
26	2.25	3.05	6.05	7.32	4.15	2.00	1.55	3.05	5.75	2.30	1.30	2.00
27	2.50	3.00	7.80	7.35	4.65	2.15	2.50	2.90	5.15	2.00	1.40	2.20
28	2.40	3.00	6.80	7.80	4.70	1.00	2.65	2.50	4.55	2.35	1.40	2.20
29	2.35	2.80	5.70	7.85	3.75	2.05	2.55	1.95	3.40	2.50	1.40	2.35
30	2.50	.....	4.82	8.05	3.35	2.30	2.50	1.45	7.55	2.35	1.30	2.90
31	2.30	.....	4.12	.....	2.35	.....	2.50	1.25	.....	2.20	.....	3.40

NOTE.—Ice corrections made to gage heights and ice curve applied January 1 to March 22 and November 27 to December 31, 1904.

Mean daily discharge, in second-feet, of West Canada Creek at Twin Rock Bridge, N. Y., for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.[ae]	Apr.[e]	May.[c]	June.[c]	July.[c]	Aug.[c]	Sept.[c]	Oct.[c]	Nov.[ac]	Dec.[a]
1	712	288	424	2,630	4,680	468	856	454	210	2,960	398	248
2	750	254	450	3,350	6,140	496	1,100	370	224	900	482	248
3	220	254	492	3,320	5,630	488	1,010	298	289	878	440	242
4	220	237	520	2,480	5,450	370	746	238	1,180	384	454	214
5	220	262	750	2,320	5,700	378	878	210	956	440	426	202
6	220	220	750	2,270	5,950	746	1,420	1,280	724	496	352	202
7	237	220	781	2,610	5,390	680	928	646	727	482	329	197
8	(b)	579	1,140	3,380	5,210	1,450	384	529	412	454	320	197
9	(b)	816	1,550	6,540	4,070	2,700	398	724	398	433	334	192
10	(b)	509	1,390	9,640	2,900	5,510	370	316	370	900	343	270
11	(b)	860	1,190	7,150	1,490	1,490	238	278	412	3,960	316	238
12	(b)	730	1,090	4,810	856	856	238	278	398	3,850	298	334
13	(b)	617	860	3,810	900	680	280	266	702	2,240	289	384
14	(b)	579	750	3,210	790	440	280	278	878	768	270	170
15	(b)	492	670	2,320	544	426	238	289	928	510	278	185
16	(b)	458	560	1,690	2,800	468	280	190	984	468	298	180
17	237	390	500	1,650	2,610	440	280	190	510	482	298	180
18	228	339	490	1,770	1,900	405	266	288	426	629	298	259
19	280	296	475	1,610	1,180	370	252	224	482	426	298	190
20	322	305	520	1,500	1,350	352	245	3,320	680	398	298	190
21	330	305	492	1,360	2,380	361	210	d6,860	1,350	5,390	311	200
22	356	398	a509	1,480	1,380	405	210	4,400	856	2,660	311	200
23	356	655	c2,055	1,820	1,300	668	200	3,270	595	1,490	298	210
24	390	721	3,040	2,760	746	510	205	1,940	812	928	320	224
25	475	636	3,900	7,260	928	412	238	702	3,580	746	252	343
26	305	926	5,260	7,010	1,280	370	289	702	2,570	454	252	343
27	390	904	7,710	7,040	1,680	412	510	646	2,080	370	256	384
28	356	904	6,260	7,710	1,670	210	561	510	1,560	468	256	384
29	339	492	4,810	7,790	1,040	384	527	361	856	510	256	426
30	390	.....	3,750	8,090	884	454	510	278	4,460	468	242	595
31	322	.....	2,960	.....	468	.....	510	245	.....	426	.....	790

[a] January 1 to March 22, and November 27 to December 31, from ice curve.
[b] Record not available.
[c] May 1 to November 26 from curve for obstructed channel.
[d] Estimated; above curve.
[e] March 23 to April 30, inclusive, from curve for unobstructed channel.

Estimated monthly discharge of West Canada Creek at Twin Rock Bridge, N. Y., for 1904.

[Drainage area, 364 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January, 22 days	750	220	348	0.956	0.782
February	926	220	505	1.39	1.50
March	7,710	424	1,808	4.97	5.73
April	9,640	1,360	4,013	11.00	12.28
May	6,140	468	2,553	7.01	8.08
June	5,510	210	795	2.18	2.43
July	1,420	200	473	1.30	1.50
August	6,860	190	984	2.70	3.11
September	4,460	210	1,019	2.80	3.12
October	5,390	370	1,160	3.19	3.68
November	482	242	319	.876	.978
December	790	170	278	.764	.881

EAST CANADA CREEK AT DOLGEVILLE, N. Y.

This creek rises in Hamilton County, flows southward between Herkimer and Fulton counties, and empties into Mohawk River at East Creek. A portion of the stream and drainage area is included on the Little Falls sheet of the United States Geological Survey Topographic Atlas. Observations are taken at High Falls, near Dolgeville, about 7 miles from the outlet of the stream. The gaging station is located at the dam of the Herkimer County Light and Power Company. Readings of the depth on the crest are taken from a vertical gage board attached to the bulkhead, 6 feet upstream, twice each day by Willard Hayward. The mean of the readings is used in computing the discharge. A record is also kept of the run of the water wheels and the elevation of water in the tailrace.

The dam is of rubble masonry 19 feet high and has a flat crest 6 feet in width and 190.25 feet long between abutments. The elevation of the upstream edge of the crest is 1 foot below that of the lip. The impounded water is conducted to the power house, 500 feet below the dam, through a wrought-iron flume 10 feet in diameter. The record since January 1, 1903, has been computed from a discharge curve based on United States Geological Survey experiments on a full-sized model of the dams made at Cornell University. The flow through the turbines for this period has also been computed from current-meter

measurements made in the tailrace of the electric-power plant, instead of from the manufacturers' rating tables for the water wheels, as formerly. The turbines are of a special Victor cylinder gate type; the two main wheels are each 36 inches in diameter and their speed is controlled by Lombard governors. Spruce Creek is the principal tributary of East Canada Creek. It enters East Canada Creek 1 mile above Dolgeville and drains an area of 50 square miles. Water is diverted from this stream at Diamond Hill and from Beaver Creek, one of its tributaries, and is carried to Little Falls through a vitrified conduit 9 miles in length. The water supply of Dolgeville is taken from Cold Brook, a tributary of East Canada Creek. No allowance for diversion for water supply has been made in computing the run-off for East Canada Creek.

The observations at this station during 1904 have been made under the direction of R. E. Horton, district hydrographer.

Mean daily discharge, in second-feet, of East Canada Creek at Dolgeville, N. Y., for 1903 and 1904.

Day.	Jan.[a]	Feb.[a]	Mar.[a]	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1903.												
1	669	1,530	3,020	2,510	415	95	1,510	250	736	174	283	93
2	826	1,630	2,320	2,080	394	99	1,220	246	578	182	277	162
3	917	1,130	1,970	2,110	297	80	815	185	457	149	232	219
4	1,210	1,160	1,560	2,590	263	80	662	355	347	97	214	159
5	881	1,640	1,140	1,840	306	100	527	1,250	245	974	196	177
6	939	1,300	1,010	1,500	95	85	561	913	[b]180	827	405	177
7	752	1,120	991	1,740	257	38	566	988	.....	523	298	151
8	667	865	1,080	2,660	217	112	561	657	229	861	257	129
9	573	641	3,290	2,080	252	199	428	673	123	5,580	262	175
10	583	623	3,200	2,080	[b]38	422	258	1,020	196	5,970	221	183
11	474	643	7,120	1,760	191	179	182	769	152	3,040	185	201
12	434	1,720	5,530	1,450	191	1,290	175	1,240	124	1,760	196	191
13	516	1,710	4,390	1,280	129	1,740	116	913	(b)	1,220	207	215
14	435	1,440	3,600	1,100	125	1,190	124	716	126	833	196	171
15	414	1,220	3,090	1,030	110	1,050	175	428	149	785	233	216
16	319	886	2,870	988	105	675	248	342	168	633	281	177
17	406	628	2,470	889	[b]66	605	219	307	112	523	571	202
18	409	591	2,290	788	121	671	190	177	172	1,770	852	175
19	229	485	2,770	741	139	694	296	211	121	1,320	557	199
20	287	583	3,530	696	105	578	363	533	[b]117	994	587	247
21	338	825	4,690	644	109	1,500	423	461	124	664	455	676
22	1,030	864	4,640	600	109	1,940	440	304	119	625	397	694
23	860	724	5,510	596	109	2,640	661	140	127	546	432	535
24	683	746	6,610	596	[b]66	3,610	724	159	125	500	384	478
25	595	600	4,130	557	125	1,800	465	740	134	423	371	368
26	851	478	2,720	510	95	1,970	384	2,200	120	381	329	400
27	468	378	2,080	510	101	1,420	390	1,480	[b]125	364	148	276
28	634	1,040	1,920	447	95	979	263	1,120	134	364	210	288
29	669	.....	1,580	447	95	914	248	954	134	412	168	220
30	1,290	.....	379	415	65	834	390	1,000	128	387	137	236
31	1,300	.....	2,810	.....	[b]61	.....	316	868	.....	222	.....	238

[a] Approximate. [b] Sunday.

Mean daily discharge, in second-feet, of East Canada Creek at Dolgeville, N. Y., for 1903 and 1904—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1904.												
1	170	121	165	1,310	3,870	334	288	188	160	1,590	344	172
2	207	135	225	1,510	3,040	297	272	261	160	1,020	314	143
3	189	145	235	1,700	3,040	297	221	266	271	731	279	105
4	195	133	428	1,430	2,930	267	206	188	418	712	871	70
5	194	124	425	1,610	2,590	408	216	150	344	504	647	162
6	158	146	415	1,610	2,080	688	221	208	261	450	450	143
7	196	189	423	1,860	1,600	616	252	151	225	302	204	134
8	171	313	673	2,920	1,300	408	216	144	188	307	245	165
9	174	356	808	4,790	1,060	1,420	146	155	176	241	243	137
10	229	363	808	5,440	838	1,300	189	188	165	862	223	121
11	160	335	761	4,090	766	804	184	133	166	2,380	225	59
12	178	311	665	3,120	476	547	166	123	145	1,659	223	121
13	185	306	596	2,310	394	413	307	123	150	1,179	251	137
14	174	278	492	1,780	352	362	199	21	160	920	276	167
15	177	257	359	1,420	579	325	151	123	385	751	215	157
16	146	177	341	1,300	999	381	162	128	283	523	223	178
17	114	206	364	1,040	843	289	164	122	266	441	158	137
18	124	165	291	999	650	242	795	160	126	435	121	74
19	132	178	282	920	650	206	325	149	166	419	132	140
20	150	183	292	726	847	174	162	3,103	162	412	131	140
21	164	183	297	771	775	216	141	2,737	329	4,229	168	125
22	188	179	282	722	608	247	136	1,481	183	3,681	162	148
23	176	241	626	1,250	519	199	131	1,574	161	1,990	149	180
24	129	241	950	2,040	496	151	107	1,039	283	1,298	157	78
25	158	215	1,330	3,970	493	141	167	688	809	901	162	98
26	160	195	1,910	3,680	493	136	245	576	1,255	773	141	76
27	183	212	2,330	3,390	498	141	245	165	867	1,782	136	173
28	172	233	2,170	4,470	530	155	266	274	828	646	98	1,285
29	167	187	1,650	4,100	509	155	736	245	809	494	516	1,062
30	160	.....	1,480	4,020	334	221	432	240	1,988	431	150	867
31	147	.....	1,440	.....	371	.....	297	175	.....	353	.....	896

Estimated monthly discharge of East Canada Creek at Dolgeville, N. Y., for 1903 and 1904.

[Drainage area, 256 square miles.]

Month.	Discharge in second-feet.			Run-off.		Rainfall.[c]
	Maximum.	Minimum.[a]	Mean.	Second-feet per square mile.	Depth in inches.	Inches.
1903.						
January	1,300	.....	[b]666	2.60	3.00	2.30
February	1,720	.....	[b]971	3.79	3.95	2.38
March	7,120	.....	[b]3,041	11.88	13.70	6.75
April	2,660	.....	1,241	4.85	5.41	1.63
May	415	.....	156	.610	.703	.18
June	3,610	.....	920	3.59	4.01	8.68
July	1,510	.....	448	1.75	2.02	5.71
August	2,200	.....	695	2.71	3.12	7.26
September	736	.....	187	.730	.814	1.30
October	5,970	.....	1,068	4.17	4.81	8.34
November	852	.....	318	1.24	1.38	2.10
December	694	.....	257	1.00	1.15	1.57
The year	.....	.....	.....	.....	44.12	48.20
1904.						
January	229	.....	169	.660	.761	.....
February	363	.....	217	.848	.915	.....
March	2,330	.....	758	2.96	3.41	.....
April	5,440	.....	2,343	9.15	10.21	.....
May	3,870	.....	1,114	4.35	5.02	.....
June	1,420	.....	385	1.50	1.67	.....
July	795	.....	250	.977	1.13	.....
August	3,103	.....	493	1.93	2.23	.....
September	1,988	.....	396	1.55	1.73	.....
October	4,229	.....	1,046	4.09	4.72	.....
November	871	.....	254	.992	1.11	.....
December	1,285	.....	247	.965	1.11	.....
The year	5,440	.....	639	2.50	33.91	.....

[a] One day minimum controlled by pondage.
[b] Approximate, owing to ice obstruction.
[c] At Salisbury Inlet.

SCHOHARIE CREEK AT PRATTSVILLE, N. Y.

Schoharie Creek above Prattsville drains a rugged mountainous area almost entirely wooded. The watershed, embracing an area of 243 square miles, lies wholly within Greene County. The basin is surrounded by continuous mountain ranges, and intervening ridges divide the main stream from its principal tributaries, Batavia Kill, East Kill, and West Kill. A gaging station was established at the highway bridge in the village of Prattsville, November 7, 1902, by C. C. Covert; the gage datum is referred to the United States Geological Survey bench mark, an "O" marked on a bowlder on the right-hand end of the bridge on the downstream side; elevation 1,151 feet. A 15-foot weight and wire gage, having a boxed horizontal scale, is attached to the steel floor beams of the bridge on the upstream side. The elevation of the water surface when the gage reads zero is 1,130.03. The bridge has a single span of 185 feet. In extreme low water the current underneath the bridge is sluggish and meter measurements are made by fording the stream a short distance below the bridge. The great freshet of October 9–11, 1903, apparently changed the stream bed and cross section in the vicinity of the gage. Measurements made during 1903 and 1904 have been applied toward the construction of a new rating curve.

The observations at this station during 1904 have been made under the direction of R. E. Horton, district hydrographer.

Discharge measurements of Schoharie Creek at Prattsville, N. Y., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Sq. feet.	*Feet per sec.*	*Feet.*	*Sec.-feet.*
July 1	R. E. Horton	404	0.71	5.00	287
September 21	C. C. Covert	269	.26	4.45	71
September 21	do	65	1.08	4.45	[a]70
October 23	C. C. Covert and E. F. Weeks.	775	1.50	6.16	1,117
October 23	do	693	1.44	6.00	998
October 24	do	682	1.11	5.72	756

[a] Wading below station.

Mean daily gage height, in feet, of Schoharie Creek at Prattsville, N. Y., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.56	5.34	5.85	5.59	6.42	5.61	5.00	4.50	4.35	4.60	4.80	5.10
2	5.56	5.21	5.70	7.39	6.09	5.21	4.65	4.50	4.35	4.50	4.80	5.10
3	5.96	5.71	7.55	6.14	5.88	4.98	4.52	4.50	4.35	4.45	4.75	5.35
4	5.96	5.81	5.95	5.76	5.68	4.95	4.48	4.50	4.30	4.40	4.70	5.40
5	5.96	5.76	5.50	5.64	5.58	4.78	4.40	4.45	4.50	4.40	4.68	5.40
6	5.96	6.21	5.35	5.79	5.43	4.83	4.35	4.40	4.42	4.40	4.70	5.30
7	5.96	8.36	8.23	5.94	5.33	5.13	4.38	4.38	4.35	4.25	4.70	5.20
8	5.86	6.85	7.75	5.89	5.23	5.05	4.38	4.32	4.35	4.35	4.70	5.15
9	5.86	5.90	6.15	6.49	5.23	7.58	4.32	4.30	4.35	4.28	4.70	5.10
10	5.71	5.55	5.65	6.74	5.18	6.78	4.32	4.70	4.35	4.32	4.70	4.80
11	5.64	5.30	5.55	6.24	5.18	5.93	4.40	4.95	4.35	4.35	4.70	4.70
12	5.58	5.27	5.40	5.99	5.11	5.57	4.40	4.80	4.32	4.62	4.70	4.90
13	5.51	5.70	5.20	5.74	5.03	5.35	4.40	4.70	4.30	4.90	4.70	4.90
14	5.51	5.80	5.25	5.56	5.01	5.27	4.35	4.70	4.32	4.80	4.78	4.60
15	5.51	5.55	5.07	5.42	5.28	5.12	4.32	4.70	4.52	4.70	5.00	4.25
16	5.48	5.55	5.05	5.32	5.88	5.00	4.35	4.65	4.95	4.65	4.85	4.40
17	5.46	5.55	5.05	5.26	5.61	4.92	4.30	4.62	4.68	4.60	4.80	4.90
18	5.46	5.50	5.00	5.22	5.43	4.82	4.72	4.60	4.48	4.60	4.75	5.00
19	5.44	5.55	5.05	5.34	5.18	4.74	4.68	4.52	4.40	4.55	4.80	5.10
20	5.36	5.85	5.65	5.19	5.68	4.72	4.40	4.75	4.30	4.50	4.90	5.10
21	5.36	5.83	5.20	5.19	5.58	4.70	4.35	4.98	4.42	8.90	5.55	5.10
22	5.38	6.95	5.46	5.14	5.33	4.62	4.40	4.85	4.35	7.50	6.00	5.10
23	7.88	6.00	6.74	5.14	5.21	4.62	4.35	4.70	4.28	6.15	5.70	5.18
24	6.61	5.95	6.04	5.09	5.21	4.57	4.30	4.60	4.30	5.72	5.50	5.90
25	5.76	5.85	6.52	5.22	5.13	4.52	4.35	4.50	4.38	5.45	5.45	5.65
26	5.54	5.70	8.54	6.44	5.21	4.47	4.40	4.48	4.38	5.30	5.15	5.40
27	5.36	5.85	6.92	6.09	5.68	4.42	4.35	4.40	4.40	5.20	5.10	6.57
28	5.31	5.85	6.24	8.49	5.28	4.42	4.35	4.40	4.40	5.10	5.10	7.68
29	5.36	5.75	5.64	7.69	5.13	4.42	5.20	4.40	4.40	5.09	5.15	5.92
30	5.26	.....	5.44	6.69	5.23	4.52	4.75	4.40	4.60	5.00	5.10	5.60
31	5.26	.....	5.46	.....	5.48	.....	4.60	4.35	.....	4.95	.....	5.50

Rating table for Schoharie Creek at Prattsville, N. Y., from November 9, 1902, to October 10, 1903.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
4.60	8	6.50	997	8.40	3,780	10.30	9,200
4.70	27	6.60	1,100	8.50	3,970	10.40	9,600
4.80	48	6.70	1,210	8.60	4,212	10.50	10,000
4.90	74	6.80	1,330	8.70	4,454	10.60	10,400
5.00	103	6.90	1,455	8.80	4,696	10.70	10,800
5.10	135	7.00	1,580	8.90	4,938	10.80	11,200
5.20	168	7.10	1,710	9.00	5,180	10.90	11,600
5.30	208	7.20	1,840	9.10	5,440	11.00	12,000
5.40	252	7.30	1,980	9.20	5,700	11.10	12,460
5.50	305	7.40	2,129	9.30	5,960	11.20	12,920
5.60	350	7.50	2,270	9.40	6,220	11.30	13,380
5.70	404	7.60	2,420	9.50	6,480	11.40	13,840
5.80	462	7.70	2,570	9.60	6,784	11.50	14,300
5.90	523	7.80	2,730	9.70	7,088	11.60	14,840
6.00	590	7.90	2,890	9.80	7,392	11.70	15,380
6.10	660	8.00	3,060	9.90	7,696	11.80	15,920
6.20	733	8.10	3,230	10.00	8,000	11.90	16,460
6.30	815	8.20	3,410	10.10	8,400	12.00	17,000
6.40	904	8.30	3,590	10.20	8,800		

Logarithmic extension used above 8.0 feet gage height.

Rating table for Schoharie Creek at Prattsville, N. Y., from October 11, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
4.15	0	4.90	245	6.00	975	7.10	2,260
4.20	12	5.00	285	6.10	1,070	7.20	2,390
4.25	24	5.10	345	6.20	1,170	7.30	2,540
4.30	36	5.20	405	6.30	1,270	7.40	2,680
4.35	48	5.30	465	6.40	1,370	7.50	2,830
4.40	61	5.40	525	6.50	1,470	7.60	2,990
4.45	73	5.50	585	6.60	1,600	7.70	3,150
4.50	85	5.60	663	6.70	1,720	7.80	3,300
4.60	125	5.70	741	6.80	1,850	7.90	3,460
4.70	165	5.80	819	6.90	1,970	8.00	3,620
4.80	205	5.90	897	7.00	2,100		

Mean daily discharge, in second-feet, of Schoharie Creek at Prattsville, N. Y., 1902–1904

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1												168
2												168
3												300
4												350
5												310
6												300
7												300
8												300
9											252	276
10											252	252
11											252	230
12											252	208
13											230	168
14											208	168
15											206	168
16											208	168
17											208	2,350
18											208	1,840
19											168	718
20											168	590
21											168	556
22											168	5,960
23											135	1,980
24											135	923
25											230	696
26											276	625
27											252	523
28											325	492
29											208	474
30											208	416
31												416
1903.												
1	366	556	2,610	1,120	188	38	433	97	1,710	88	345	285
2	377	398	1,190	718	176	38	340	74	733	97	285	345
3	682	1,160	833	718	176	38	252	74	462	88	265	345
4	774	1,330	675	860	168	38	168	80	325	88	255	345
5	492	774	639	660	161	38	168	474	290	88	245	330
6	404	625	625	590	135	31	168	492	290	108	.....	265
7	404	625	523	590	135	31	161	450	252	97	275	245
8	398	523	815	696	135	31	135	276	243	733	255	245
9	377	492	2,080	1,580	135	61	109	208	188	(a)	255	235
10	377	433	1,580	904	119	44	108	217	168	7,390	245	205
11	404	404	3,320	696	129	74	103	176	176	3,685	235	205
12	404	1,460	1,910	590	108	2,850	88	168	168	2,050	235	205
13	377	733	1,310	511	97	1,840	74	142	142	1,530	225	205
14	377	462	1,050	462	103	815	74	135	142	1,170	205	936
15	404	416	1,310	1,270	108	1,910	74	108	109	936	205	819
16	404	660	1,050	950	108	1,840	61	108	135	741	215	741
17	377	696	923	860	88	860	61	108	142	682	540	741
18	377	(b)	774	696	74	625	69	108	511	702	800	663
19	377	.....	696	577	74	462	88	108	276	682	975	663
20	377	.....	660	492	61	377	108	1,050	168	570	702	2,830
21	404	.....	749	450	61	1,645	377	815	161	495	465	2,610

a Above rating curve. b Frozen.

Mean daily discharge, in second-feet, of Schoharie Creek at Prattsville, N. Y., etc.—Cont'd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1903.												
22	450	.....	3,410	393	61	1,520	340	696	135	465	405	1,220
23	361	.....	7,315	252	61	1,190	217	646	129	435	420	819
24	377	.....	3,780	350	61	2,460	161	511	119	450	405	741
25	355	.....	1,910	300	48	1,270	109	556	109	435	390	721
26	590	.....	1,270	300	48	815	97	696	103	420	435	624
27	523	.....	886	276	48	556	80	416	103	390	465	496
28	815	.....	660	243	48	433	74	860	119	390	.....	525
29	.....	.....	625	217	48	462	80	4,575	109	390	405	570
30	2,340	.....	523	200	48	718	142	2,770	103	360	315	682
31	749	.....	2,270	.....	44	.....	109	2,650	.....	345	.....	663
1904.												
1	624	495	(a)	663	1,400	663	285	85	48	125	205	345
2	624	(a)	.....	2,680	1,070	405	145	85	48	85	205	345
3	936	.....	.....	1,120	878	275	95	85	48	73	185	495
4	(a)	.....	.....	780	721	265	79	85	36	61	165	525
5	.....	.....	.....	702	643	195	61	73	85	61	155	525
6	.....	.....	.....	819	540	215	48	61	67	61	165	465
7	.....	.....	.....	936	480	360	54	54	48	24	165	405
8	.....	.....	.....	897	420	315	54	42	48	48	165	375
9	.....	.....	.....	1,470	420	2,950	42	36	48	31	165	345
10	.....	.....	.....	1,750	390	1,820	42	165	48	42	165	205
11	.....	.....	.....	1,220	390	917	61	265	48	48	165	165
12	.....	.....	.....	975	345	643	61	205	42	135	165	245
13	.....	.....	.....	780	300	495	61	165	36	245	165	245
14	.....	.....	.....	624	285	450	48	165	42	205	195	125
15	.....	.....	.....	540	450	360	42	165	95	165	285	24
16	.....	.....	.....	480	878	285	48	145	265	145	225	61
17	.....	.....	.....	435	663	255	36	135	155	125	205	245
18	.....	.....	.....	420	540	215	175	125	79	125	185	285
19	.....	.....	.....	495	390	185	155	95	61	105	205	345
20	.....	.....	(a)	405	721	175	61	185	36	85	245	345
21	.....	.....	405	405	643	165	48	275	67	(b)	624	345
22	(a)	.....	555	375	480	135	61	225	48	2,830	975	345
23	3,420	.....	1,780	375	405	135	48	165	31	1,120	741	390
24	1,600	.....	1,000	345	405	115	36	125	36	780	585	897
25	780	.....	1,500	420	360	95	48	85	54	555	555	702
26	624	.....	(b)	1,420	405	79	61	79	54	465	375	525
27	495	.....	2,010	1,070	721	67	48	61	61	405	345	1,560
28	465	.....	1,220	(b)	450	67	48	61	61	345	345	3,110
29	495	.....	702	3,150	360	67	405	61	61	285	375	917
30	435	.....	555	1,720	420	95	185	61	125	285	345	663
31	435	.....	555	.....	570	.....	125	48	.....	265	.....	585

a Stream frozen over; no record.

b Above rating table.

Estimated monthly discharge of Schoharie Creek at Prattsville, N. Y., 1902–1904.

[Drainage area, 240 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
November, 22 days	325	135	214	0.892	0.730
December	5,960	168	722	3.01	3.47
1903.					
January, 30 days	2,340	361	516	2.15	2.40
February, 17 days	1,460	393	691	2.88	1.82
March	7,315	523	1,547	6.45	7.44
April	1,580	200	617	2.57	2.87
May	188	44	98	.408	.470
June	2,850	31	770	3.21	3.58
July	433	61	149	.621	.716
August	4,575	74	639	2.66	3.07
September	1,710	103	261	1.09	1.22
October, 30 days	(a)	88	870	3.62	4.17
November, 28 days	975	205	374	1.56	1.62
December	2,830	205	662	2.76	3.18
1904.					
January, 12 days [b]	3,420	435	911	3.80	1.70
February [b]					
March, 10 days [b]	(a)	405	1,028	4.28	1.59
April, 29 days	(a)	345	947	3.95	4.26
May	1,400	285	553	2.30	2.65
June	3,070	67	415	1.73	1.93
July	405	36	89	.371	.428
August	275	36	118	.492	.567
September	265	31	66	.275	.307
October, 30 days	(a)	24	310	1.29	1.44
November	975	155	302	1.26	1.41
December	3,110	24	521	2.17	2.50

[a] Above rating table. [b] Stream frozen over January 4 to 22 and February 2 to March 20.

BATAVIA KILL NEAR PRATTSVILLE, N. Y.

Batavia Kill enters Schoharie Creek just above Prattsville. The gaging of this stream at Windon near the headwaters was made September 10, 1903, by F. H. Tillinghast. The discharge was 21 second-feet.

CATSKILL CREEK AT SOUTH CAIRO, N. Y.

The drainage basin of this stream receives the run-off from the north slope of the Catskill Range, and lies, for the most part, in the timbered highlands of Greene County. The stream enters tide water of Hudson River at Catskill. The topography of the drainage area is shown on the Durham, Coxsackie, and Catskill sheets of the United States Geological Survey Topographic Atlas. The stream flows over a rock bed through much of its course. The slopes of the drainage basin are precipitous; there are no lakes and little artificial storage.[a] The gaging station, which was established July 4, 1901, is located at the highway bridge in the village of South Cairo. The bridge has a single span of 194.5 feet between abutments. The stream channel is rock overlain in some places with earth. The stream stage is observed each morning and night from a weight and chain gage which is attached to the bridge, and whose elevation is referred to a "0" near outer corner on upstream side of bridge seat on right-hand abutment. The elevation of bench mark is assumed to be 100 feet, the elevation of water surface when gage reads zero is 78.71 feet. Special discharge measurements have been made in the winter to determine the calibration curve for the stream cross section in the presence of ice; a correction coefficient to be applied to the measured discharge as taken at 0.6 depth has also been obtained by means of numerous vertical-velocity curves. The erection of a dam a short distance below the gage for purposes of boating necessitates withholding a portion of the record for 1904 until additional measurements can be made.

The observations at this station during 1904 have been made under the direction of R. E. Horton, district hydrographer.

Discharge measurements of Catskill Creek at South Cairo, N. Y., in 1904.

Date.	Hydrographer.	Area.	Mean velocity.	Gage height.	Discharge.[b]
		Sq. feet.	*Feet per sec.*	*Feet.*	*Second-feet.*
June 28[c]	R. E. Horton	45	1.10	2.62	50
September 16	Covert and Swancott	272	.32	2.90	88

[a] Water power of this stream is described in Report on Stream Gagings, contained in Supplement, Report of State Engineer and Surveyor of New York, 1902, pp. 260 to 264.
[b] Discharge affected by dam one-fourth mile below station.
[c] By wading 500 feet upstream.

Mean daily gage height, in feet, of Catskill Creek at South Cairo, N. Y., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.[a]	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.29	4.56	3.50	5.24	5.04	3.38	3.00	2.45	2.30	2.40	3.10	3.65
2	4.17	4.46	3.45	7.19	4.59	3.23	2.80	2.40	2.20	2.40	3.00	3.35
3	4.32	4.31	3.50	5.69	4.54	3.23	2.50	2.40	2.10	2.40	2.90	3.20
4	4.17	4.66	5.55	4.59	4.39	3.13	2.50	2.40	2.40	2.40	2.80	3.30
5	4.17	4.56	6.05	4.74	4.18	4.23	2.55	2.40	2.20	2.50	2.85	3.25
6	4.12	4.26	5.40	4.84	4.08	3.58	2.40	2.40	2.20	2.40	2.90	3.10
7	4.07	4.28	8.20	4.94	3.88	3.43	2.35	2.30	2.20	2.40	2.90	3.00
8	3.92	6.98	7.90	4.89	3.73	3.88	2.30	2.30	2.30	2.40	2.80	2.90
9	3.87	4.51	5.85	5.29	3.58	9.15	2.40	2.40	2.30	2.30	2.70	3.00
10	3.82	4.86	4.88	5.24	3.53	6.75	2.50	2.40	2.30	2.30	2.70	2.75
11	3.72	4.58	4.20	4.89	3.48	5.25	2.40	2.50	2.30	2.40	2.60	2.40
12	3.62	4.31	4.30	4.69	3.33	4.67	2.40	2.60	2.30	2.50	2.60	2.20
13	3.57	3.52	4.20	4.49	3.28	4.17	2.30	2.45	2.20	2.60	2.60	2.30
14	3.47	4.24	4.30	4.29	3.13	4.02	2.30	2.45	2.30	2.70	3.00	2.40
15	3.52	4.08	3.90	4.14	3.28	3.92	2.30	2.50	3.10	2.60	3.00	2.40
16	3.47	4.01	3.65	4.09	4.51	3.72	2.30	2.40	2.70	2.50	3.40	2.60
17	3.36	3.88	3.20	4.19	4.13	3.52	2.30	2.35	2.50	2.50	3.40	2.75
18	3.36	3.86	3.80	4.39	3.88	3.42	2.45	2.40	2.30	2.50	3.40	2.65
19	3.36	4.01	3.90	4.59	4.08	3.27	2.40	2.40	2.30	2.50	3.35	2.70
20	3.36	3.88	5.20	4.14	4.13	3.02	2.40	2.30	2.30	2.60	3.15	2.80
21	3.36	3.61	5.05	3.89	3.88	2.92	2.40	2.30	2.30	4.75	3.80	2.80
22	3.44	4.26	4.95	3.89	3.63	2.92	2.30	2.30	2.30	5.30	4.70	2.80
23	5.14	4.87	7.10	3.94	3.48	2.92	2.30	2.40	2.30	4.55	4.60	3.00
24	5.26	4.73	6.40	3.84	3.33	2.72	2.20	2.40	2.30	4.15	4.60	3.10
25	4.51	3.90	6.80	3.94	3.23	2.62	2.30	2.40	2.30	3.95	4.45	3.10
26	4.36	3.63	8.35	3.94	3.73	2.62	2.30	2.40	2.20	3.80	4.05	3.20
27	4.54	3.50	7.35	4.32	4.23	2.52	2.40	2.35	2.30	3.70	3.85	3.40
28	4.96	3.30	5.55	8.54	3.63	2.52	2.40	2.30	2.30	3.60	3.80	6.15
29	4.96	3.35	4.40	6.76	3.33	2.50	2.75	2.20	2.30	3.35	3.80	4.90
30	4.96	.....	4.60	5.79	3.33	2.70	2.60	2.20	2.45	3.20	3.90	4.00
31	4.96	.....	4.59	.....	3.48	.....	2.55	2.20	.....	3.10	.....	3.80

[a] After June 1 gage heights affected by dam below station.

Rating table for Catskill Creek at South Cairo, N. Y., for open section from July 4, 1901, to June 1, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.20	16	4.20	401	6.40	1,900	10.40	11,764
2.30	20	4.30	449	6.60	2,106	10.60	12,700
2.40	24	4.40	498	6.80	2,328	10.80	13,700
2.50	28	4.50	546	7.00	2,550	11.00	14,700
2.60	37	4.60	602	7.20	2,822	11.20	15,780
2.70	45	4.70	657	7.40	3,094	11.40	16,860
2.80	55	4.80	712	7.60	3,406	11.60	18,000
2.90	63	4.90	768	7.80	3,758	11.80	19,200
3.00	72	5.00	824	8.00	4,110	12.00	20,400
3.10	88	5.10	885	8.20	4,562	12.20	21,920
3.20	104	5.20	946	8.40	5,014	12.40	23,440
3.30	120	5.30	1,006	8.60	5,498	12.60	25,000
3.40	136	5.40	1,067	8.80	6,014	12.80	26,600
3.50	152	5.50	1,128	[a] 9.00	6,530	13.00	28,200
3.60	182	5.60	1,206	9.20	7,178	13.50	34,000
3.70	213	5.70	1,285	9.40	7,826	14.00	39,800
3.80	243	5.80	1,363	9.60	8,524	14.50	45,600
3.90	274	5.90	1,442	9.80	9,272	15.00	51,400
4.00	304	6.00	1,520	10.00	10,020	15.50	57,200
4.10	352	6.20	1,710	10.20	10,892	16.00	63,000

[a] Extension by logarithmic diagram above 9.1.

Mean daily discharge, in second-feet, of Catskill Creek at South Cairo, N. Y., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	Day.	Jan.	Feb.	Mar.	Apr.	May.
1	[a]	[a]	[a]	970	848	17	.....	.....	104	396	367
2	.....	.....	.....	2,810	596	18	.....	.....	243	498	268
3	.....	.....	.....	1,280	568	19	.....	.....	274	596	358
4	.....	.....	1,170	596	493	20	.....	.....	946	372	367
5	.....	.....	1,570	679	391	21	.....	.....	854	270	268
6	.....	.....	1,070	735	318	22	.....	.....	796	270	192
7	.....	440	4,560	791	268	23	909	.....	2,690	286	149
8	.....	2,530	3,930	763	222	24	982	.....	1,900	255	125
9	.....	552	1,400	1,000	176	25	552	.....	2,330	286	109
10	.....	746	729	970	161	26	478	.....	4,900	286	222
11	.....	590	401	763	149	27	[a]	.....	3,090	459	415
12	.....	454	449	652	125	28	.....	.....	1,170	5,340	192
13	.....	158	401	541	117	29	.....	.....	498	2,280	125
14	.....	420	449	444	93	30	.....	.....	602	1,360	125
15	.....	343	274	372	117	31	.....	.....	596	.....	149
16	.....	[a]	198	348	552						

[a] Stream frozen over during remainder of month.

Estimated monthly discharge of Catskill Creek at South Cairo, N. Y., for 1904.

[Drainage area, 263 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January, 4 days [a]	982	478	730	2.78	0.414
February, 9 days [a]	2,530	158	693	2.64	0.884
March, 28 days [a]	4,900	104	1,340	5.10	5.31
April	5,340	255	889	3.38	3.77
May	848	93	278	1.06	1.22

[a] Stream frozen over during remainder of month.

ESOPUS CREEK NEAR OLIVEBRIDGE, N. Y.

A ⅞-inch wire cable, 168-feet span, was erected across the stream 300 feet above Bishops Falls, May 25, 1903. A cantilever was also projected 18 feet over the stream from an abandoned bridge abutment. Upon this a weight and chain gage was placed. The stream was observed twice each day by Jesse B. Boice. This station is located near the site of a proposed storage reservoir. The bed of the stream is rock and the banks bold. No overflow takes place. The gaging station is in the heart of a precipitous timber-covered mountain drainage basin. There is no storage control of the stream above. The bench mark is a chisel draft at upstream corner of the right-hand abutment of the abandoned bridge. The elevation of water surface when gage reads zero is 81.86. This station site was selected by, and the cableway erected for, the engineers of the New York Water-Supply Commission, to show the relation between the discharge at this point and at Kingston. Owing to the formation of a gravel bar at the mouth of a tributary entering at the cableway the record was discontinued in July, 1904.

The observations at this station during 1904 have been made under the direction of R. E. Horton, district hydrographer.

Discharge measurements of Esopus Creek near Olivebridge, N. Y., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.[a]
		Sq. feet.	*Feet per sec.*	*Feet.*	*Sec.-feet.*
June 30	R. E. Horton	158	1.11	1.35	143

[a] Gravel Island, upstream angle varies.

Mean daily gage height, in feet, of Esopus Creek near Olivebridge, N. Y., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	Day.	Jan.	Feb.	Mar.	Apr.	May.	June.
1	1.82	1.94	1.71	3.19	2.96	1.66	17	2.36	1.76	1.79	2.16	2.03	1.87
2	1.78	1.72	1.77	3.35	2.67	1.70	18	2.38	1.77	1.90	2.09	2.02	1.73
3	1.77	1.82	2.12	2.96	2.50	1.81	19	2.36	1.88	1.97	2.04	2.11	1.67
4	1.72	1.74	2.20	2.63	2.38	1.67	20	2.42	1.89	2.25	1.96	2.30	1.67
5	1.70	1.79	1.93	2.57	2.26	1.61	21	2.48	1.85	2.09	1.94	2.16	1.64
6	1.72	1.77	1.87	2.49	2.18	1.61	22	2.74	1.86	2.07	1.90	2.06	1.61
7	2.08	2.86	3.25	2.67	2.10	1.96	23	3.60	2.34	2.65	1.86	2.01	1.56
8	2.56	3.18	4.45	2.81	2.02	1.94	24	2.68	2.09	2.77	1.84	1.97	1.50
9	2.60	2.52	3.27	3.49	1.97	3.20	25	2.28	1.94	3.05	1.91	1.94	1.47
10	2.66	2.30	2.78	3.55	1.91	3.15	26	2.20	1.81	5.21	2.07	1.93	1.41
11	2.62	2.26	2.53	3.08	1.89	2.49	27	2.12	1.91	4.03	2.12	1.88	1.35
12	2.62	2.10	2.33	2.81	1.81	2.25	28	1.97	1.87	3.15	3.89	1.80	1.81
13	1.94	2.07	2.25	2.61	1.76	2.06	29	2.04	1.77	2.75	3.78	1.70	1.31
14	2.50	2.04	2.12	2.44	1.72	1.99	30	1.97	.....	2.52	3.21	1.70	1.44
15	2.38	1.96	2.05	2.30	2.06	1.87	31	1.96	.....	2.42	.....	1.67	.....
16	2.38	1.78	1.97	2.27	2.20	1.87							

Rating table for Esopus Creek near Olivebridge, N. Y., from May 25, 1903, to June 30, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.00	55	2.30	815	3.60	2,610	4.90	5,100
1.10	81	2.40	911	3.70	2,770	5.00	5,320
1.20	107	2.50	1,010	3.80	2,940	5.10	5,560
1.30	138	2.60	1,140	3.90	3,100	5.20	5,790
1.40	173	2.70	1,280	4.00	3,270	5.30	6,030
1.50	208	2.80	1,420	4.10	3,460	5.40	6,280
1.60	263	2.90	1,550	4.20	3,650	5.50	6,500
1.70	318	3.00	1,690	4.30	3,840	5.60	6,760
1.80	381	3.10	1,840	4.40	4,030	5.70	7,020
1.90	453	3.20	1,990	4.50	4,220	5.80	7,280
2.00	525	3.30	2,140	4.60	4,440	5.90	7,540
2.10	622	3.40	2,290	4.70	4,660	6.00	7,800
2.20	718	3.50	2,440	4.80	4,880		

Note.—Discharge for gage heights above 5 feet from logarithmic extension of rating curve.

Mean daily discharge, in second-feet, of Esopus Creek near Olivebridge, N. Y., for 1903 and 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1903.												
1						60	815	124	1,975	117	307	323
2						68	622	110	1,392	112	301	318
3						65	482	104	970	112	296	285
4						39	453	155	796	97	285	323
5						52	410	1,140	622	112	381	381
6						55	340	670	511	115	323	323
7						52	307	699	439	104	241	219
8						117	268	475	367	892	274	213
9						152	252	395	329	(a)	274	208
10						84	230	367	296	7,020	274	235
11						124	201	307	252	3,202	263	274
12						3,940	183	381	235	2,110	257	307
13						2,290	187	285	230	1,446	241	1,406
14						1,662	152	252	208	1,080	230	603
15						2,290	141	219	187	931	230	439
16						1,840	131	246	176	737	252	439
17						1,308	97	241	489	660	796	410
18						1,010	99	208	544	853	1,080	367
19						815	208	187	323	699	853	279
20						853	159	1,080	263	670	680	1,676
21						3,202	252	641	230	603	583	2,706
22						2,260	180	453	208	544	564	1,480
23						2,220	345	410	201	544	535	980
24						3,460	219	374	180	518	503	825
25					94	2,290	173	352	169	511	446	815
26					81	1,480	152	381	159	388	359	825
27					60	1,080	134	307	159	367	340	482
28					73	796	127	395	166	352	352	467
29					68	1,088	110	7,072	145	345	296	395
30					68	931	145	3,992	131	340	329	446
31					68		148	3,308		312		403
1904.												
1	395	482	323	1,975	1,634	296	296					
2	367	329	359	2,220	1,288	398	190					
3	359	395	641	1,634	1,010	388	159					
4	329	340	718	1,182	892	301	145					
5	318	374	475	1,101	776	268						
6	329	359	431	1,000	699	268						
7	603	1,498	2,060	1,238	622	496						
8	1,088	1,960	4,120	1,433	544	482						
9	1,140	1,036	2,095	2,425	503	1,990						
10	1,224	815	1,392	2,520	460	1,920						
11	1,168	776	1,049	1,810	446	1,000						
12	1,168	622	844	1,433	388	766						
13	482	593	766	1,154	352	583						
14	1,010	564	641	951	329	518						
15	892	496	573	815	583	431						
16	892	367	503	786	718	431						
17	873	352	374	680	554	431						
18	892	359	458	612	544	334						
19	873	439	503	564	632	301						
20	931	446	766	496	815	301						

a Above rating table.

Mean daily discharge, in second-feet, of Esopus Creek near Olivebridge, N. Y., etc.—Cont'd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1904.												
21	990	417	612	482	680	285	.....	.....	.....	.....	.....	.....
22	1,336	424	593	458	583	268	.....	.....	.....	.....	.....	.....
23	2,610	853	1,210	424	535	241	.....	.....	.....	.....	.....	.....
24	1,252	612	1,378	410	503	208	.....	.....	.....	.....	.....	.....
25	796	482	1,760	460	482	197	.....	.....	.....	.....	.....	.....
26	718	388	5,814	593	475	176	.....	.....	.....	.....	.....	.....
27	641	460	3,327	641	439	155	.....	.....	.....	.....	.....	.....
28	503	431	1,920	3,084	381	388	.....	.....	.....	.....	.....	.....
29	564	359	1,350	2,906	318	141	.....	.....	.....	.....	.....	.....
30	503	.....	1,036	2,005	318	187	.....	.....	.....	.....	.....	.....
31	496	.....	931	.....	301	.....	.....	.....	.....	.....	.....	.....

Estimated monthly discharge of Esopus Creek near Olivebridge, N. Y., for 1903 and 1904.

[Drainage area, 242 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1903.					
May 25–31	94	60	73	0.302	0.079
June	3,940	39	1,189	4.91	5.48
July	815	97	249	1.03	1.19
August	7,072	104	817	3.38	3.90
September	1,975	131	412	1.70	1.90
October, 30 days	(a)	97	863	3.57	3.98
November	1,080	230	405	1.67	1.86
December	2,706	208	608	2.51	2.89
1904.					
January	2,610	318	830	3.43	3.95
February	1,960	329	587	2.43	2.62
March	5,814	323	1,259	5.20	6.00
April	3,084	410	1,250	5.17	5.77
May	1,634	301	605	2.50	2.88
June	1,990	141	472	1.95	2.18

a Above rating table.

ESOPUS CREEK AT KINGSTON, N. Y.

A gaging station was established at the Washington Street Bridge on Esopus Creek, in Kingston, N. Y., July 5, 1901. The stage of the stream has been observed twice each day from a chain and weight gage attached to the bridge. In winter and at times when the stream

was more or less obstructed by ice special discharge measurements were made from which a rating curve applicable to periods when the stream was frozen have been derived. This gives a considerably smaller discharge at a given stage of the stream than does a regular rating curve for the cross section derived from the measurements in open section.

The observations at this station during 1904 have been made under the direction of R. E. Horton, district hydrographer.

Discharge measurements of Esopus Creek at Kingston, N. Y., in 1904.

Date.	Hydrographer.	Area.	Mean velocity.	Gage height.	Discharge.
		Sq. ft.	*Ft. per sec.*	*Feet.*	*Second-feet.*
June 20	R. E. Horton	255	0.84	4.72	214
September 15	Covert and Swancott	506	2.28	7.18	[a] 1,161
September 19	do	269	1.04	5.15	281

[a] Approximate; stream rising rapidly.

Mean daily gage height, in feet, of Esopus Creek at Kingston, N. Y., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	7.61	7.41	7.26	10.85	9.35	5.44	6.27	4.32	4.37	4.82	5.58	5.52
2	7.41	6.16	7.26	11.48	8.60	5.40	5.18	4.32	4.30	4.58	5.48	5.50
3	6.71	7.01	7.36	10.13	8.05	5.80	4.85	4.28	4.31	4.50	5.38	5.55
4	6.26	6.96	9.45	9.08	7.70	5.50	4.74	4.29	4.81	4.52	5.30	5.88
5	6.71	6.81	8.15	8.62	7.37	5.31	4.65	4.19	4.70	4.32	5.25	5.40
6	6.69	6.73	7.74	8.41	7.09	5.30	4.62	4.22	4.57	4.32	5.32	5.32
7	6.89	7.46	9.26	8.53	6.85	6.72	4.66	4.09	4.36	4.38	5.32	5.42
8	6.83	12.17	18.23	8.92	6.63	6.27	4.65	4.11	4.29	4.30	5.15	5.30
9	6.71	9.85	14.85	10.07	6.46	12.14	4.59	4.19	4.30	4.25	5.10	5.29
10	6.81	8.99	12.18	10.89	6.32	11.14	4.48	4.21	4.31	4.28	5.10	4.90
11	6.71	8.51	10.95	9.82	6.19	6.63	4.48	6.25	4.29	4.35	5.02	4.80
12	6.46	8.31	10.00	9.03	6.06	7.91	4.45	5.04	4.09	4.42	4.98	4.74
13	6.36	7.86	9.10	8.47	5.92	7.23	4.45	4.76	4.24	4.90	4.90	5.12
14	6.41	7.76	8.65	8.00	5.82	6.79	4.34	4.62	4.44	4.88	5.80	5.00
15	6.37	7.56	8.25	7.62	5.92	6.46	4.30	4.46	7.22	4.70	5.65	4.88
16	6.26	7.41	7.80	7.52	7.28	6.19	4.28	4.42	6.54	4.54	5.62	5.18
17	6.16	6.99	7.40	7.22	6.83	5.93	4.33	4.26	5.68	4.50	5.72	5.12
18	5.99	6.86	7.60	7.09	6.62	5.71	4.59	4.36	5.33	4.60	5.52	5.08
19	5.79	6.92	7.10	6.86	6.73	5.50	4.88	4.52	5.14	4.58	5.42	5.12
20	5.81	6.82	7.78	6.72	7.45	5.40	4.58	5.06	4.90	4.50	5.35	5.15
21	5.76	6.72	8.39	6.58	7.01	5.29	4.36	6.11	4.80	11.29	5.88	5.12
22	6.11	7.91	8.04	6.41	7.67	5.16	4.26	5.44	4.68	13.84	6.40	5.02
23	7.96	9.73	9.02	6.27	6.45	5.01	4.28	5.31	4.62	9.09	6.25	5.05
24	10.91	8.51	9.74	6.17	6.31	5.10	4.23	5.13	4.59	8.42	6.18	5.15
25	9.41	8.09	9.95	6.21	6.08	4.95	4.10	4.83	4.52	7.20	6.12	5.80
26	8.61	7.46	14.63	6.58	6.11	4.75	4.40	4.83	4.50	6.82	5.95	5.48
27	8.26	7.41	13.66	6.75	6.11	4.70	4.33	4.65	4.55	6.55	5.70	5.45
28	7.76	7.33	10.50	9.60	5.75	4.69	4.33	4.57	4.52	6.25	6.00	10.50
29	7.66	7.31	9.20	11.53	5.58	4.70	4.18	4.47	4.50	6.02	5.92	9.65
30	7.76	.....	8.40	9.85	5.51	4.72	4.82	4.44	4.70	5.85	6.00	8.71
31	7.55	.....	8.28	.....	5.58	.....	4.51	4.37	.....	5.70	.....	8.18

Rating table for Esopus Creek at Kingston, N. Y., from July 5, 1901, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.50	8	6.60	741	11.20	3,620	17.20	9,940
3.60	22	6.70	782	11.40	3,800	17.40	10,180
3.70	36	6.80	823	11.60	3,980	17.60	10,420
3.80	49	6.90	864	11.80	4,160	17.80	10,660
3.90	63	7.00	905	12.00	4,340	18.00	10,900
4.00	77	7.10	950	12.20	4,528	18.20	11,220
4.10	94	7.20	995	12.40	4,716	18.40	11,540
4.20	110	7.30	1,040	12.60	4,909	18.60	11,840
4.30	127	7.40	1,085	12.80	5,107	18.80	12,120
4.40	143	7.50	1,130	13.00	5,305	19.00	12,400
4.50	160	7.60	1,179	13.20	5,499	19.20	12,720
4.60	180	7.70	1,227	13.40	5,693	19.40	13,040
4.70	200	7.80	1,276	13.60	5,888	19.60	13,340
4.80	220	7.90	1,324	13.80	6,084	19.80	13,620
4.90	240	8.00	1,373	14.00	6,280	20.00	13,900
5.00	260	8.20	1,480	14.20	6,484	20.20	14,240
5.10	285	8.40	1,587	14.40	6,688	20.40	14,580
5.20	309	8.60	1,700	14.60	6,894	20.60	14,920
5.30	334	8.80	1,820	14.80	7,102	20.80	15,260
5.40	358	9.00	1,940	[a]15.00	7,310	21.00	15,600
5.50	383	9.20	2,074	15.20	7,522	21.50	16,500
5.60	412	9.40	2,208	15.40	7,734	22.00	17,400
5.70	441	9.60	2,348	15.60	7,950	22.50	18,350
5.80	469	9.80	2,495	15.80	8,170	23.00	19,300
5.90	498	10.00	2,642	16.00	8,390	23.50	20,300
6.00	527	10.20	2,797	16.20	8,666	24.00	21,300
6.10	562	10.40	2,952	16.40	8,942	24.50	22,350
6.20	596	10.60	3,112	16.60	9,204	25.00	23,400
6.30	631	10.80	3,276	16.80	9,452	25.50	24,500
6.40	665	11.00	3,440	17.00	9,700	26.00	25,600
6.50	700						

[a] Logarithmic extension above 15 feet.

Mean daily discharge, in second-feet, of Esopus Creek at Kingston, N. Y., for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.[a]	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	955	868	808	3,320	2,170	368	620	130	138	224	406	389
2	868	450	808	3,870	1,700	358	304	130	127	176	378	388
3	608	707	848	2,740	1,400	469	230	123	128	160	353	397
4	476	690	1,960	1,990	1,230	383	208	125	222	164	334	492
5	608	641	1,220	1,710	1,070	335	190	108	200	130	321	[b]277
6	608	616	1,020	1,590	946	334	184	113	174	130	339	257
7	674	888	1,840	1,660	844	790	192	92	137	140	339	277
8	649	3,710	(c)	1,890	753	620	190	96	125	127	297	257
9	608	2,210	5,410	2,700	686	4,480	178	108	127	119	284	257
10	641	1,680	3,710	3,360	638	3,570	157	112	128	123	284	180
11	608	1,400	3,000	2,510	593	753	157	614	125	135	264	163
12	529	1,300	2,310	1,960	548	1,330	152	270	92	147	256	146
13	502	1,070	1,740	1,620	504	1,010	152	212	117	240	240	217
14	516	1,020	1,480	1,370	475	819	133	184	150	236	469	197
15	509	932	1,270	1,190	504	686	127	153	1,004	200	426	180
16	476	868	1,050	1,140	1,030	593	123	147	716	168	418	237
17	450	707	868	1,000	835	507	132	120	434	160	447	217
18	410	658	955	945	742	443	178	137	341	180	389	217
19	365	682	747	848	794	383	236	164	294	176	363	217
20	365	649	1,270	790	1,110	358	176	274	240	160	346	237
21	354	616	1,580	733	910	331	137	565	220	3,700	492	217
22	436	1,090	1,390	669	1,210	299	120	368	196	6,120	665	197
23	1,120	2,130	1,950	620	683	262	123	336	184	2,000	613	197
24	2,900	1,400	2,450	586	634	285	115	292	178	1,600	589	237
25	1,930	1,190	2,600	600	555	250	94	226	164	995	569	365
26	1,460	888	6,920	733	565	210	143	226	160	831	512	297
27	1,270	868	5,940	803	565	200	132	190	170	720	440	277
28	1,030	838	3,030	2,350	455	198	132	174	164	613	527	[d]2,660
29	978	828	2,070	3,910	406	200	107	155	160	534	504	2,050
30	1,030	.....	1,590	2,530	386	204	224	150	200	484	527	1,510
31	932	.....	1,520	.....	406	.....	162	138	.....	440	.....	1,240

[a] Record from January 1 to March 20 from ice curve.
[b] Record from December 5 to December 31, inclusive, from ice curve.
[c] Above rating table.
[d] Record approximate. Ice jam below bridge December 28 to 31.

Estimated monthly discharge of Esopus Creek at Kingston, N. Y., for 1904.

[Drainage area, 324.5 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	2,900	354	802	2.47	2.85
February	3,710	450	1,089	3.36	3.62
March, 30 days	6,920	747	2,112	6.51	7.26
April	3,910	586	1,725	5.32	5.94
May	2,170	386	818	2.52	2.91
June	4,480	198	701	2.16	2.41
July	620	94	178	.549	.633
August	614	92	201	.619	.714
September	1,004	92	227	.700	.781
October	6,120	119	688	2.12	2.44
November	665	240	413	1.27	1.42
December	2,660	146	466	1.44	1.66

WAPPINGER CREEK NEAR WAPPINGER FALLS, N. Y.

This station was established at the first highway bridge crossing Wappinger Creek above the village of Wappinger Falls, May 19, 1903.

Observations of the stage of the stream on a graduated vertical scale attached to the central bridge pier are taken twice each day by Lee Jackson. Wappinger Creek is tributary to Hudson River. The drainage basin comprises a hilly plateau 400 to 600 feet above tide, nearly rectangular in shape, and including numerous small lakes and marsh areas. Winding branched tributaries gather the run-off from the numerous hills which dot the area. At a point about 16 miles from the mouth of the stream the basin becomes much narrower and the differences of elevation are of less magnitude. The stream flows near the right-hand side of a valley 3 to 4 miles in width, gradually descending to Wappinger Falls, where it makes a sudden descent to nearly tide-water level, the elevation of the Wappinger Pond being about 78 feet.[a]

Drainage areas of Wappinger Creek.

Location.	Area, place to place.	Total area, square miles.
East Branch of Wappinger Creek above Stanfordville	40.0	40.0
East Branch above junction with West Branch	67.4	107.4
West Branch above mouth	33.8	33.8
Total area of East and West branches		141.2
Wappinger Creek above Van Wagner's	33.8	175.0
Wappinger Creek above Central Falls	14.7	189.7
Wappinger Creek above gaging station	4.78	194.4
Wappinger Creek above Wappinger Falls	7.81	202.2
Wappinger Creek above mouth	13.7	215.9

The bridge from which the gagings are made has two spans of 43.4 feet and 46.5 feet, respectively. The channel of the stream is sand and gravel, with some bowlders. The stream is straight for a distance of about 250 feet above the bridge and about 300 feet downstream from the bridge. The bench mark is a spike in the root of blazed tree, south side of road, 50 feet east of bridge. Assumed elevation is 100.00 feet. Elevation above datum plane of gage is 90.81 feet. But little power is developed on the stream. At Wappinger Falls a bleaching and dyeing establishment utilizes 22 feet fall.

The observations at this station during 1904 have been made under the direction of R. E. Horton, district hydrographer.

[a] The drainage basin is shown on the Poughkeepsie, Rhinebeck, Millbrook, and Clove sheets of the United States Geological Survey Topographic Atlas, from which the drainage area as given has been determined.

Discharge measurements of Wappinger Creek near Wappinger Falls, N. Y., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Sq. feet.	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
June 29	R. E. Horton	151	0.57	0.45	86
September 17	Covert and Swancott	325	1.35	2.04	438

Mean daily gage height, in feet, of Wappinger Creek near Wappinger Falls, N. Y., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.20	3.70	2.90	2.75	2.00	1.15	2.20	0.45	−0.10	0.90	0.90	1.00
2	2.20	3.70	2.75	3.20	1.80	1.00	1.55	.15	− .10	.92	.88	1.22
3	2.20	3.70	4.20	2.85	1.55	.95	1.10	.15	− .05	.80	.85	1.30
4	.....	3.70	6.95	2.55	1.50	.95	.85	.15	− .05	.75	.82	1.40
5	.....	3.70	5.00	2.20	1.45	.95	.85	.15	.00	.72	.80	1.38
6	.....	2.80	3.70	2.00	1.35	1.55	1.10	.15	− .05	.70	.80	1.35
7	.....	3.45	3.65	2.05	1.25	1.55	.80	.15	− .05	.65	.80	1.30
8	.....	4.85	8.60	2.05	1.15	1.40	.65	.15	.05	.62	.78	1.30
9	2.20	3.30	7.65	2.05	1.15	4.75	.55	.10	− .05	.60	.75	1.30
10	2.20	3.10	7.05	2.05	1.05	3.95	.55	.15	.10	.58	.72	1.30
11	.....	3.10	6.30	2.05	1.05	3.10	.60	.45	.15	.52	.70	1.30
12	.....	3.10	4.70	1.95	.95	2.25	.65	.90	.05	1.00	.70	1.30
13	.....	3.10	4.65	1.90	.90	1.90	.60	.60	− .05	1.42	.70	1.30
14	.....	3.10	2.95	1.80	.85	1.65	.50	.45	.85	1.15	1.00	1.30
15	.....	3.10	1.75	1.75	.85	1.50	.45	.25	3.00	.95	1.30	1.30
16	2.20	3.10	1.55	1.65	.85	1.30	.45	.15	2.85	.78	1.22	1.30
17	2.20	3.10	1.45	1.65	1.05	1.15	.45	.15	1.95	.75	1.18	1.30
18	2.20	3.10	1.45	1.55	1.20	1.00	.80	.15	1.48	.72	1.12	1.30
19	2.20	3.10	1.55	1.40	1.20	.95	1.20	.15	1.28	.70	.95	1.30
20	2.20	3.10	2.65	1.35	1.15	.85	.70	.25	1.08	.65	.90	1.30
21	2.20	3.10	2.40	1.25	1.05	.85	.55	.25	1.00	1.75	.82	1.30
22	2.20	3.20	2.10	1.15	.95	.75	.50	.40	.85	2.95	.72	1.30
23	2.40	4.45	2.55	1.05	.90	.70	.45	.15	.78	2.20	.65	1.30
24	5.15	4.20	2.70	1.05	.85	.65	.45	− .25	.72	1.72	.60	1.30
25	4.10	3.45	2.50	1.05	.85	.65	.43	− .20	1.12	1.52	.78	1.40
26	3.75	2.95	2.55	1.10	1.40	.65	.35	.10	1.25	1.42	.98	1.30
27	3.70	2.80	2.70	1.15	2.95	.55	.35	.05	1.18	1.38	.90	1.58
28	3.70	2.90	2.30	2.90	2.00	.50	.35	.05	1.00	1.25	1.22	4.40
29	3.70	3.30	1.85	2.85	1.25	.60	.35	.05	.98	1.12	1.25	4.05
30	3.30	.....	1.95	2.35	1.25	.90	.35	− .05	.95	1.00	1.18	3.50
31	3.70	.....	1.95	.....	1.35	.....	.45	.00	.....	.95	.....	3.20

CROTON RIVER AT OLD CROTON DAM, NEW YORK.

Croton River drains an area of rough, irregular topography situated east of Hudson River, to which it is tributary at Croton Landing. A gaging record has been maintained, beginning January, 1868, at the old Croton dam. The record includes the amount wasted over the dam and the diversion to New York City for municipal supply through Croton aqueduct.[a] The following table shows the monthly mean dis-

[a] Full description of methods of gaging, and results for the years 1868 to 1899, inclusive, may be found in Supplement, State Engineer's Report for 1902. Report on Gagings of the Volume of Discharge of Streams, by Robert E. Horton, hydrographer, pp. 290-299, inclusive.

charge at the Croton dam from July, 1901, to September, 1903, inclusive. The data given has been deduced from a table of yield in gallons per square mile per day, given in Report of New York Water Supply Commission, page 220. The drainage area above the old Croton dam is 338.8 square miles, comprising 3.6 per cent water surface.

Estimated monthly discharge of Croton River at old Croton dam, New York, 1901–1903.

[Drainage area, 339 square miles.]

Month.	Mean discharge in second-feet.	Gallons per square mile per day.	Run-off.	
			Second-feet per square mile.	Depth in inches.
1901.				
July	393	749,000	1.16	1.34
August	1,119	2,131,000	3.30	3.80
September	644	1,232,000	1.90	2.12
October	752	1,432,000	2.22	2.56
November	359	685,000	1.06	1.18
December	1,308	2,491,000	3.86	4.45
1902.				
January	1,166	2,223,000	3.44	3.97
February	803	1,529,000	2.37	2.47
March	2,962	5,638,000	8.74	10.08
April	922	1,759,000	2.72	3.03
May	515	982,000	1.52	1.75
June	241	458,000	.711	.793
July	220	422,000	.649	.748
August	183	352,000	.540	.623
September	170	322,000	.501	.559
October	654	1,246,000	1.93	2.22
November	451	860,000	1.33	1.48
December	1,484	2,827,000	4.38	5.05
The year			2.40	32.77
1903.				
January	1,050	1,998,000	3.10	3.57
February	1,156	2,202,000	3.41	3.54
March	1,776	3,380,000	5.24	6.04
April	1,027	1,957,000	3.03	3.38
May	210	399,000	.619	.714
June	956	1,818,000	2.82	3.15
July	454	867,000	1.34	1.54
August	454	867,000	1.34	1.54
September	549	1,051,000	1.62	1.81

MISCELLANEOUS MEASUREMENTS IN HUDSON RIVER DRAINAGE BASIN.

The following miscellaneous measurements were made in the Hudson River drainage basin during 1904, by R. E. Horton.

Miscellaneous measurements in Hudson River drainage basin.

Date.	Stream.	Locality.	Gage height.	Discharge.
			Feet.	*Second-feet.*
May 18.....	Nine Mile Creek	Powell Bridge near Oriskany, N. Y.	[a] 21.04	39
September 13 ..	....do	....do	[a] 22.17	20
August 25.....	Champlain Canal feeder.	Glen Falls, N. Y.....	[b] 9.57	302

[a] Distance of water surface below the top of the outer downstream tie bar, 15 feet from the left end of the bridge.
[b] Distance of water surface below the top stone of the bridge seat at the left end, downstream side.

PASSAIC RIVER DRAINAGE BASIN.

Passaic River rises in Somerset and Morris counties, N. J. Above its confluence with Pompton River, its main tributary, it meanders through a flat country of Triassic red sandstone, to which in large measure must be attributed the turbidity of its waters. In contrast with the sluggish, muddy character of the Passaic, the Pompton is a rapid stream and its waters are clear. It drains parts of Sussex, Passaic, and Morris counties, and traverses for a large part of its course a country of hard, crystalline rocks and heavy forests, the general level of which is several hundred feet above that of the Passaic. At their confluence the Pompton enters with a current which carries it well toward the right bank of the Passaic, and at times of flood causes much backwater in the latter.

The flow of Passaic River is of special interest from the fact that several large cities in its drainage basin take their public water supply from it, and because of the valuable water-power privileges along its course, particularly at the city of Paterson. Several cities, including Paterson and Passaic, throw their sewage into this stream, and in the lower part of its course it becomes so polluted as to be offensive to property holders along its banks and to seriously interfere with the comfort and health of the inhabitants of several towns.

The highest recorded flood which has occurred on this drainage basin was that of October, 1903. The estimated discharge at Dundee dam was 35,800 second-feet. This flood is fully described in Water-Supply Paper No. 92. The flood began at 6.30 p. m. October 8, 1903, and lasted until midnight October 18, 1903, the maximum height being reached at 9 p. m. October 10, 1903. There was a total rainfall of 11.74 inches in thirty-six hours.

The United States Geological Survey maintained gaging stations in this basin in 1904 as follows: Passaic River at Millington, N. J.; Passaic River near Chatham, N. J.; Pompton River at Pompton Plains, N. J.; Ramapo River near Mahwah, N. J.; Wanaque River near Wanaque, N. J.; Rockaway River near Boonton, N. J.

PASSAIC RIVER AT MILLINGTON, N. J.

This station was established November 25, 1903, by F. H. Tillinghast. It is located at the lower highway bridge at Millington, N. J. The standard boxed chain gage is fastened to the wooden hand rail on the downstream side of the bridge. The pulley wheel is located at a point 24 feet from the right abutment. The length of the chain from the end of the weight to the marker is 14.17 feet. Bench mark No. 1 is a square chisel draft on the corner of the right abutment at the downstream side. Its elevation is 11.82 feet above gage datum. Bench mark No. 2 is the top of a nail 2 feet from the ground in an elm tree 150 feet east of the bridge. Its elevation is 13.57 feet above gage datum. Bench mark No. 3 is the top of the circular iron bridge chord or tension bar directly under the pulley. Its elevation is 8.97 feet above gage datum. Bench mark No. 4 is the top of the wooden rail of the bridge at the pulley. Its elevation is 13.44 feet above gage datum. Discharge measurements are made from the downstream side of the old wooden truss bridge, to which the gage is attached. The bridge has a span of 69.7 feet. The initial point for soundings is the vertical face of the right abutment on the downstream side. The channel is straight for 600 feet above and 200 feet below the station. The current has a moderate velocity. Both banks are high, without trees, and are not subject to overflow. The bed of the stream is composed of gravel, with a few scattered bowlders, and is permanent. The section is shallow. There is but one channel at all stages. The gage is read twice each day by Mary I. Bray.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Passaic River at Millington, N. J., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 9	F. H. Tillinghast	65	90	1.48	2.12	133.
May 13	F. H. Brundage	57	37.2	1.02	1.36	37.8
June 4	J. C. Hoyt	63	63.	1.19	1.65	75.
August 1	do	55	27.	.77	1.20	21.
November 9	H. D. Comstock	62	44.	.88	1.42	38.

Mean daily gage height, in feet, of Passaic River at Millington, N. J., for 1904.

Month.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.22	2.60	3.00	3.45	2.30	1.95	1.25	1.28	1.25	1.30	1.60	1.42
2	2.15	2.55	2.92	4.00	2.45	1.82	1.15	1.58	1.20	1.30	1.50	1.35
3	2.15	2.50	3.00	3.50	2.20	1.78	1.10	1.85	1.20	1.30	1.48	1.32
4	2.12	2.50	3.45	2.90	2.02	1.60	1.10	1.58	1.20	1.30	1.52	1.25
5	2.10	2.45	3.18	2.52	1.88	1.60	1.03	1.60	1.20	1.30	1.48	1.88
6	2.08	2.42	2.98	2.28	1.72	1.62	1.10	2.05	1.12	1.30	1.42	1.88
7	2.05	2.45	3.90	2.20	1.68	1.65	1.20	2.00	1.10	1.25	1.40	1.58
8	2.00	2.98	7.18	2.12	1.65	1.68	1.65	1.95	1.18	1.20	1.40	1.52
9	2.00	2.90	6.05	2.15	1.55	1.65	1.72	1.98	1.12	1.35	1.40	1.40
10	2.00	2.65	3.95	2.35	1.50	1.62	1.38	1.90	1.12	1.32	1.40	1.38
11	2.00	2.60	2.62	2.25	1.52	1.52	1.35	2.52	1.10	1.30	1.52	1.40
12	2.00	2.55	2.28	2.08	1.45	1.38	1.28	2.58	1.10	1.72	1.52	1.48
13	2.00	2.50	2.18	2.00	1.35	1.32	1.38	2.40	1.10	1.90	1.70	1.50
14	2.15	2.45	2.08	1.90	1.40	1.25	1.22	2.12	1.60	1.85	2.42	1.50
15	2.15	2.42	1.98	1.78	1.52	1.28	1.15	1.88	4.92	1.68	2.45	1.50
16	2.15	2.40	1.95	1.70	1.48	1.22	1.12	1.65	4.80	1.55	2.22	1.52
17	2.15	2.35	1.90	1.60	1.45	1.20	1.08	1.52	4.80	1.42	2.10	1.55
18	2.15	2.35	1.90	1.60	1.42	1.20	1.20	1.40	3.75	1.40	1.92	1.65
19	2.15	2.35	2.25	1.60	1.45	1.20	1.25	1.35	3.25	1.40	1.78	1.65
20	2.12	2.35	3.00	1.55	1.55	1.18	1.15	2.32	2.80	1.40	1.70	1.65
21	2.10	2.35	2.82	1.55	1.38	1.15	1.15	2.75	2.40	2.35	1.68	1.65
22	2.15	5.92	2.75	1.50	1.38	1.15	1.08	2.60	2.08	4.05	1.60	1.65
23	4.78	6.72	3.05	1.50	1.30	1.10	1.08	2.40	1.80	3.40	1.52	1.68
24	5.90	6.45	2.98	1.40	1.30	1.10	1.08	2.25	1.62	3.10	1.50	1.70
25	5.00	5.12	2.85	1.42	1.30	1.05	1.12	1.95	1.58	2.72	1.50	1.78
26	3.88	3.50	2.75	1.42	1.30	1.05	1.10	1.65	1.50	2.40	1.45	1.90
27	2.80	2.75	2.78	1.75	1.15	1.10	1.10	1.48	1.45	2.18	1.40	1.95
28	2.68	2.82	2.51	2.45	1.18	1.10	1.10	1.40	1.42	1.92	1.65	2.18
29	2.65	3.35	2.35	2.55	1.20	1.12	1.52	1.32	1.35	1.80	1.60	2.28
30	2.65	.....	2.20	2.45	1.22	1.20	1.45	1.30	1.40	1.72	1.38	2.25
31	2.60	.....	2.38	.....	1.90	.....	1.25	1.25	.....	1.68	.....	2.25

NOTE.—River frozen from January 1 to March 8. February 22, highest reading, 7.00; March 8, highest reading, 7.50.
During the frozen period the gage heights are to the surface of the ice.

PASSAIC RIVER NEAR CHATHAM, N. J.

This station was established February 10, 1903, by the United States Weather Bureau, by which it is maintained. It is located at the second bridge, about 1½ miles upstream from Chatham, N. J. The original gage consists of a 2 by 12 inch board spiked to the upstream wing wall of the right abutment. On December 12, 1903, a standard chain gage was installed on the downstream side of the bridge; the length of the chain from the end of the weight to the marker is 15.59 feet. Bench mark No. 1 for the new gage is the corner of the top of the right abutment on the upstream side. Its elevation is 10.31 feet above the datum of the chain gage. Bench mark No. 2 is the upper surface of the upper chord directly over the gage pulley. Its elevation is 17.91 feet above gage datum. Bench mark No. 3 is the upper surface of the lower chord directly under the pulley. Its elevation is 9.19 feet above gage datum. Bench mark No. 4 is the top of the first bolt on the coping of the downstream wing wall, right hand abutment. Its elevation is 10.64 feet above gage datum. Discharge measurements are made from the single-span steel highway bridge, to which the gage is attached. The downstream side is marked every 5 feet. The initial point for soundings is the base of the right abutment. The channel is straight for 400 feet above and below the station and the current swift. At low water the current makes a small angle with the normal to the cross section, caused by a small island just below the bridge. Two hundred feet above the bridge is an old timber dam partly washed away. Both banks are high and wooded, and are not liable to overflow. The bed of the stream is composed of gravel, with occasional bowlders. The gage reader for the Weather Bureau is M. A. Butler.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements on Passaic River near Chatham, N. J., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 9	F. H. Tillinghast	66	146	1.61	3.25	235
May 14	F. H. Brundage	64	80	.65	2.52	52
June 4	J. C. Hoyt	70	106	.96	2.80	102
August 1	do	70	76	.43	2.40	33
November 9	H. D. Comstock	70	92	.63	2.61	58

Mean daily gage height, in feet, of Passaic River near Chatham, N. J., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	[a] 3.00	3.80	5.60	3.90	3.40	3.00	2.10	2.40	2.40	2.50	2.70	2.40
2	2.70	3.60	5.20	4.70	3.50	3.00	2.10	2.50	2.40	2.50	2.70	2.40
3	2.70	3.40	4.70	4.50	3.40	2.90	2.10	3.20	2.40	2.40	2.60	2.40
4	2.70	(a)	6.00	4.10	3.20	2.80	2.10	3.40	2.30	2.40	2.60	2.40
5	2.70	(a)	5.90	3.70	3.10	2.70	2.10	3.10	2.30	2.40	2.50	2.30
6	2.70	3.40	5.20	3.40	2.90	2.70	2.10	4.40	2.30	2.40	2.50	2.30
7	2.70	3.70	4.60	3.30	3.80	2.80	2.20	4.20	2.30	2.30	2.50	2.30
8	2.70	5.50	6.80	3.30	2.80	2.70	2.70	3.70	2.22	2.30	2.50	2.30
9	2.70	5.10	6.00	3.30	2.70	2.80	3.10	3.30	2.22	2.30	2.60	(a)
10	2.70	(a)	5.60	3.50	2.70	2.70	3.00	3.00	2.22	2.30	2.60	(a)
11	2.70	(a)	[b] 5.00	3.30	2.70	2.60	2.80	4.60	2.20	2.30	2.70	(a)
12	2.70	(a)	4.00	3.30	2.60	2.60	2.60	4.20	2.20	2.70	2.90	(a)
13	3.10	(a)	3.50	3.20	2.60	2.50	2.40	3.90	2.10	3.50	3.20	(a)
14	3.50	(a)	3.40	3.00	2.50	2.40	2.50	3.50	2.10	3.30	3.80	(a)
15	3.40	(a)	3.30	2.90	2.60	2.40	2.40	3.20	6.00	2.90	3.70	(a)
16	3.20	(a)	3.20	2.90	2.80	2.30	2.30	3.00	5.50	2.80	3.50	(a)
17	3.00	(a)	3.00	2.80	2.70	2.30	2.30	2.80	5.20	2.80	3.10	(a)
18	3.00	(a)	3.00	2.80	2.60	2.30	2.40	2.50	5.00	2.70	3.00	(a)
19	3.00	(a)	3.50	2.70	2.60	2.30	2.50	2.30	4.30	2.70	2.90	(a)
20	3.00	(a)	3.70	2.70	2.70	2.20	2.40	2.70	4.20	2.60	2.90	(a)
21	3.20	(a)	3.40	2.70	2.80	2.20	2.30	4.00	3.60	2.60	2.80	(a)
22	4.00	6.70	3.70	2.60	2.70	2.20	2.30	3.90	3.40	4.60	2.80	(a)
23	[c] 4.50	7.50	3.90	2.60	2.60	2.20	2.30	3.70	3.00	4.50	2.70	2.50
24	7.60	[c] 7.90	3.90	2.60	2.40	2.20	2.30	3.50	2.90	4.30	2.70	2.70
25	7.20	7.60	3.70	2.60	2.40	2.10	2.30	3.20	2.80	3.90	2.70	(a)
26	6.70	7.50	3.60	2.60	2.40	2.10	2.30	3.00	2.70	3.60	2.70	(a)
27	6.10	6.50	3.60	2.80	2.30	2.10	2.30	2.70	2.70	3.20	2.60	(a)
28	5.00	5.60	3.50	4.00	2.30	2.10	2.20	2.60	2.60	3.00	2.50	3.50
29	4.50	5.70	3.40	3.90	2.30	2.10	2.60	2.50	2.50	2.90	2.50	4.00
30	4.00	.....	3.30	3.50	2.30	2.10	2.70	2.50	2.50	2.80	2.50	3.60
31	3.90	.....	3.20	.....	2.60	.....	2.60	2.40	.....	2.70	.....	3.30

[a] River frozen January 1 to March 10, inclusive; also December 9–22 and December 25–27, inclusive. Gage heights to surface of ice.
[b] River clear.
[c] Ice jam.

POMPTON RIVER AT POMPTON PLAINS, N. J.

This station measures the combined flow of Pequannock, Wanaque, Ramapo, and Pompton rivers. It was established March 7, 1903, by the United States Weather Bureau, by which it is maintained. It is located at a 254-foot timber dam situated about half a mile east of Pompton Plains railroad station. The dam constitutes a portion of the headworks of the Morris canal feeder at Pompton Plains. A cast-iron gage is bolted vertically to the framework of the lock gates at the entrance to the canal. The gage reader for the Weather Bureau is E. M. Le Fevre, who reads the gage every morning. The main portion and crest of the dam is timber 6 inches in width. The downstream face is vertical, and 2.7 feet below the crest is an apron. The upstream side of the dam is paved. Starting at a point 6 inches below the crest of the dam, the paving is placed downward and upstream at a slope of 6 inches in 3 feet. The rating table for this dam was constructed as follows: The Francis formula was used, modified by comparison with results of experiments made at Cornell University. The coefficients used were those derived from United States Geological Survey experiments, Cornell series 40, for a 6-inch broad-crested weir. This gives a varying coefficient for low heads up to a depth of 0.8 foot, at which height the nappe breaks clear from the horizontal face and the weir becomes practically sharp crested, giving the Francis formula, $Q=3.33\,lh^{\frac{3}{2}}$. The crest of the dam is slightly irregular, and in order to apply the weir formula to it an accurate profile was taken and the dam was divided into a number of approximately level sections. These sections comprised all elevations between certain limiting values, whether in juxtaposition or not. Each section was computed separately for all gage heights. By combining these the flow on the entire dam, which is 254.5 feet long, was obtained for each gage reading. The rating table shows the combined discharge of all sections for the same gage heights. To the flow over the dam must be added the flow through the Morris canal feeder, records of which are maintained. All the water in times of flood passes over the dam, except in very extreme cases, as the flood of October, 1903. Bench mark No. 1 is a square chiseled on the coping of the left upstream parapet wall of the head-gates to the feeder canal. Its elevation is 11.99 feet above gage datum. Bench mark No. 2 is a square chiseled on the outside edge of the upstream parapet wall at the entrance to the feeder. Its elevation is 12.10 feet above the zero of the cast-iron gage. This station was discontinued December 31, 1904.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Mean daily gage height, in feet, of Pompton River at Pompton Plains, N. J., for 1904.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		4.90		4.60	4.80	3.70	3.80	4.10	4.40	4.40
2		5.50		4.60	4.50	3.70	3.80	4.10	4.30	4.40
3		5.20		4.60	4.20	3.70	3.80	4.10	4.20	4.40
4		5.00		4.50	4.10	3.70	3.80	4.10	4.10	4.40
5				4.50	4.00	3.70	3.80	4.10	4.00	4.40
6				4.50	4.00	3.70	3.80	4.10	4.10	4.40
7				4.40	4.00	3.70	3.80	4.10	4.10	4.40
8	7.50			4.40	4.00	3.70	3.80	4.10	4.10	4.40
9	6.40			4.80	4.20	3.70	3.80	4.10	4.10	4.40
10	5.80			4.80	4.00	3.70	3.90	4.10	4.10	4.40
11	5.20			4.50	4.00	3.90	3.90	4.10	4.10	4.40
12	4.80			4.40	4.00	3.80	3.90	4.10	4.10	4.40
13				4.30	4.00	3.70	3.90	4.30	4.10	4.40
14				4.30	4.00	3.70	3.90	4.10	4.70	4.40
15				4.30	4.00	3.70	5.50	4.10	4.60	4.40
16				4.20	4.00	3.70	5.00	4.10	4.50	4.40
17				4.10	4.00	3.70	4.70	4.10	4.40	4.40
18			4.40	4.10	3.90	3.60	4.30	4.10	4.40	4.40
19			4.30	4.10	3.80	3.60	4.30	4.10	4.40	4.40
20			4.40	4.10	3.80	3.60	4.30	4.10	4.30	4.40
21			4.30	4.00	3.80	4.30	4.30	4.10	4.30	4.40
22			4.20	4.00	3.70	4.30	4.30	5.70	4.40	4.40
23			4.20	4.00	3.70	4.20	4.30	5.00	4.40	4.40
24			4.20	4.00	3.70	4.00	4.20	4.80	4.40	4.40
25			4.20	4.00	3.70	4.00	4.10	4.70	4.40	.....
26			4.30	3.90	3.70	3.90	4.10	4.60	4.40	.....
27			4.30	4.00	3.70	3.80	4.10	4.60	4.40	.....
28			4.30	4.00	3.70	3.80	4.10	4.60	4.40	4.70
29		5.10	4.20	4.00	3.70	3.80	4.10	4.60	4.40	4.60
30		4.90	4.20	4.00	3.80	3.80	4.10	4.50	4.40	4.50
31	4.90		4.40	.....	3.70	3.80	.....	4.40	.....	4.50

NOTE.—Gage broken from January 1 to March 7, from March 13–30, from April 5–28, and from May 1–17. River frozen December 25 to 27, inclusive.

RAMAPO RIVER NEAR MAHWAH, N. J.

This station was established February 10, 1903, by the United States Weather Bureau, by which it is maintained. It is located at a concrete-arch highway bridge about 1 mile west of Mahwah, N. J. A standard chain gage is bolted to the hand rail on the downstream side of the bridge. The length of the chain from the end of the weight to the marker is 20.65 feet. Bench mark No. 1 is a square chiseled on the coping of the upstream parapet wall at the left bank. Its elevation is 17.72 feet above gage datum. Bench mark No. 2 is a square chiseled on the edge of the coping, 3.5 feet west of the gage pulley. Its elevation is 17.43 feet above gage datum. The gage reader for the Weather Bureau is M. F. Brooks. Discharge measurements are made from the upstream side of the concrete-arch highway bridge to which the gage is attached. The bridge has a single span of 68 feet between abutments. The initial point for soundings is the end post of the hand rail on the left bank. The channel is straight for 300 feet above and 200 feet below the bridge. The current is swift. About 200 feet

below the bridge there is a rift with about 1 foot fall. The right bank is low, and during high water the lowlands on this side of the river are flooded. The left bank is high, wooded, and not liable to overflow. The bed of the stream is composed of gravel and scattered bowlders, and there is but one channel.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Ramapo River near Mahwah, N. J., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 2	F. H. Tillinghast	64	363	3.61	6.00	1,309
May 18	F. H. Brundage	57	210	.88	3.62	185
June 3	J. C. Hoyt	55	250	1.24	4.02	310
August 2	do	45	166	.16	2.65	27
November 11	Murphy and Comstock.	51	191	.48	3.26	92

Mean daily gage height, in feet, of Ramapo River near Mahwah, N. J., for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.10	4.10	4.10	4.80	4.60	4.20	5.80	2.70	2.60	3.00	3.50	3.50
2	4.00	4.00	4.00	5.90	4.40	4.40	4.80	2.70	2.50	3.00	3.50	3.40
3	[b]4.00	4.00	4.00	5.30	4.20	4.40	3.80	2.90	2.60	3.00	3.50	3.40
4	[b]4.00	4.00	5.10	4.90	4.10	4.00	3.40	2.80	2.50	2.90	3.40	3.40
5	[b]4.00	.....	4.70	4.60	4.00	3.90	3.30	2.80	2.50	2.90	3.40	3.40
6	[b]3.90	4.00	4.20	4.50	3.90	3.70	3.20	2.80	2.50	2.80	3.50	3.30
7	[b]3.90	4.00	4.20	4.40	3.90	3.60	3.10	2.80	2.50	2.70	3.50	3.30
8	[b]3.90	4.20	7.10	4.40	3.80	3.60	3.40	2.80	2.50	2.70	3.40	3.30
9	[b]3.90	4.50	6.40	4.30	3.80	4.30	3.30	2.80	2.50	2.80	3.40	3.30
10	.....	4.50	5.40	4.70	3.70	4.50	3.10	2.70	2.90	2.80	3.40	3.30
11	.....	4.50	5.10	4.50	3.70	4.10	3.10	2.80	2.70	2.80	3.40	3.20
12	.....	4.20	4.90	4.40	3.70	3.80	3.10	2.90	2.60	2.80	3.40	3.20
13	.....	4.00	4.70	4.40	3.60	3.60	3.00	2.80	2.60	3.60	3.40	3.20
14	.....	3.80	4.50	4.20	3.60	3.50	2.90	2.80	2.50	3.40	4.00	3.20
15	.....	3.80	4.80	4.20	3.60	3.50	2.90	2.80	5.70	3.20	3.80	3.20
16	.....	.....	4.20	4.10	4.10	3.40	2.90	2.80	5.80	3.10	3.80	3.20
17	[b]3.80	.....	4.10	4.00	3.90	3.30	2.80	2.70	4.30	3.10	3.80	3.20
18	[b]3.80	.....	4.10	4.00	3.80	3.30	2.80	2.70	3.70	3.00	3.70	3.20
19	[b]3.80	3.70	4.10	3.90	3.70	3.20	3.00	2.70	3.50	2.90	3.70	(c)
20	[b]3.80	3.70	4.70	3.80	3.70	3.20	2.90	2.70	3.30	2.90	3.70	(c)
21	[b]4.00	(d)	4.70	3.80	3.60	3.00	2.80	3.50	3.30	3.00	3.70	(c)
22	[b]4.20	5.20	4.50	4.80	3.50	3.00	2.70	3.60	3.20	6.90	3.95	(c)
23	5.00	5.60	4.60	4.70	3.50	3.00	2.70	3.30	3.20	5.80	4.00	(c)
24	5.90	5.20	4.80	3.70	3.40	2.90	2.70	3.00	3.10	4.70	3.90	3.40
25	4.80	5.00	4.80	3.70	3.30	2.80	2.80	2.90	3.10	4.30	3.80	3.60
26	4.60	4.50	4.70	3.70	3.50	2.80	2.90	2.80	3.10	4.10	3.70	3.60
27	4.40	4.40	5.10	3.70	3.60	2.80	2.80	2.70	3.10	4.00	3.60	.....
28	4.40	4.10	4.70	4.60	3.60	2.80	2.80	2.70	3.10	3.80	3.60	4.10
29	4.40	4.30	4.50	5.30	3.40	2.80	3.00	2.70	3.00	3.70	3.60	4.60
30	4.40	.....	4.40	4.90	3.40	2.90	2.90	2.90	3.00	3.70	3.60	4.40
31	4.20	.....	4.40	.....	4.10	.....	2.80	2.80	.....	3.60	.....	4.10

[a] River frozen January 1 to February 29. [b] Gage heights estimated. [c] River frozen. [d] Ice 2 feet.

Rating table for Ramapo River near Mahwah, N. J., from January 1, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.50	11	3.70	230	4.90	565	6.10	1,380
2.60	25	3.80	250	5.00	610	6.20	1,480
2.70	40	3.90	270	5.10	660	6.30	1,580
2.80	56	4.00	295	5.20	715	6.40	1,680
2.90	73	4.10	320	5.30	775	6.50	1,780
3.00	91	4.20	345	5.40	835	6.60	1,880
3.10	110	4.30	370	5.50	900	6.70	1,980
3.20	130	4.40	395	5.60	970	6.80	2,080
3.30	150	4.50	425	5.70	1,045	6.90	2,190
3.40	170	4.60	455	5.80	1,120	7.00	2,300
3.50	190	4.70	490	5.90	1,200	7.10	2,410
3.60	210	4.80	525	6.00	1,290		

The above table is applicable only for open-channel conditions. It is based upon discharge measurements made during 1903 and 1904. It is not well defined. Above gage height 6.80 feet the rating curve is a tangent, the difference being 110 per tenth.

Estimated monthly discharge of Ramapo River near Mahwah, N. J., for 1903 and 1904.

[Drainage area, 118 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1903.					
February 10–28	660	230	341	2.89	2.04
March	1,880	250	571	4.84	5.58
April	2,190	210	534	4.53	5.05
May	190	40	96	.814	.938
June	1,980	25	400	3.39	3.78
July	1,045	40	183	1.55	1.79
August	525	40	162	1.37	1.58
September	835	73	198	1.68	1.87
October	5,380	73	801	6.79	7.83
November	715	210	281	2.38	2.66
December[a]	.....	.....	357	3.03	3.49

[a] Frozen December 17 to 22 and 30 to 31; monthly mean estimated.

Estimated monthly discharge of Ramapo River near Mahwah, N. J., etc.—Continued.

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1904.					
January [a]	.....	.....	260	2.20	2.54
February [a]	.....	.....	300	2.54	2.74
March	2,410	295	562	4.76	5.49
April	1,200	230	430	3.64	4.06
May	455	150	247	2.09	2.41
June	425	56	191	1.62	1.81
July	775	40	123	1.04	1.20
August	210	40	66	.560	.646
September	1,120	11	152	1.29	1.44
October	2,190	40	243	2.06	2.37
November	295	170	215	1.82	2.03
December [b]	.....	.....	182	1.54	1.78
Total	2,410	11	248	2.10	28.52

[a] Ice conditions during January and February, mean flow for month estimated.
[b] Monthly mean estimated.

WANAQUE RIVER AT WANAQUE, N. J.

This station was established December 16, 1903, by F. H. Tillinghast. It is located at the highway bridge just above the Erie Railway bridge and below the factory of the Wanaque River Paper Company. The standard chain gage is situated on the upstream side of the bridge. The gage pulley is located at a point 73 feet from the right abutment. The length of the chain from the end of the weight to the marker is 17.52 feet. Bench mark No. 1 is a circular chisel draft on the upstream side of the right abutment. Its elevation is 13.80 feet above gage datum. Bench mark No. 2 is a square chisel draft on the upstream edge of the last stone upstream of the right abutment wing wall. Its elevation is 14.21 feet above gage datum. Bench mark No. 3 is the upper edge of lower chord on the upstream side of the bridge, 1.1 feet from the down spout. Its elevation is 13.58 feet above gage datum. Discharge measurements are made from the upstream side of the single-span highway bridge, which has a length between abutments of 98.5 feet. The initial point for soundings is the face of the right abutment on the upstream side. The channel is straight for 300 feet above and 200 feet below the station. The current is sluggish at low water. The right bank is high, rocky, and wooded, while the left bank is low and without trees. All water

passes under the bridge at all stages. The bed of the stream is composed of gravel, with occasional bowlders. At ordinary stages the depth of the water at the gaging section is from 2 to 5 feet. The gage is read twice daily by J. Herbert Hunter.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Wanaque River at Wanaque, N. J., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1904.		*Feet.*	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 5	F. H. Tillinghast	86	362	1.01	2.81	367
May 17	F. H. Brundage	82	292	.52	2.04	153
June 3	J. C. Hoyt	84	338	.80	2.60	269
August 5	do		202	.054	.97	11
November 10	Hoyt and Murphy	84	232	.24	1.35	56
December 10	F. H. Tillinghast	85	308	.61	2.25	187

Mean daily gage height, in feet, of Wanaque River at Wanaque, N. J., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.10	2.20	2.40	2.30								1.56
2	2.09	2.20	2.38	2.30								1.52
3	2.90	2.20	2.30	2.45								1.52
4	2.90	[a]2.15	2.28	2.80								1.40
5	2.95	2.12	2.20	2.80								1.27
6	2.90	2.10	2.20	2.70								1.42
7	2.10	2.10	4.30	2.50								1.42
8	2.10	2.10	6.30	2.40								1.40
9	2.10	2.10	5.95	2.40								1.32
10	2.10	2.10	5.25	2.40								[b]1.29
11	2.10	2.10	4.60	2.40								1.34
12	2.10	2.10	3.85	2.40								1.39
13	2.10	2.10	3.15	2.30								1.32
14	2.10	2.10	2.70	2.22								1.30
15	2.09	2.10	2.40	2.18								1.45
16	2.10	2.20	2.40	2.00								1.57
17	2.10	2.20	2.40	2.00								1.58
18	[c]	2.20	2.40	2.00								
19		2.20	2.40	1.90								
20		2.20	2.40	1.90								
21		2.30	2.40	1.90								
22		3.15	2.50	1.90								
23		2.80	2.80	1.85								
24		2.72	2.85	1.85								
25	2.50	2.70	2.80									
26	2.50	2.60	2.70									
27	2.40	2.60	2.60								1.55	
28	2.40	2.50	2.40								1.62	
29	[d]2.30	2.50	2.40								1.65	
30	2.28		2.30								1.60	
31	2.20		2.30									

[a] River open. [b] River frozen. [c] Gage broken. [d] Ice 6 inches thick.

ROCKAWAY RIVER NEAR BOONTON, N. J.

This station was established March 15, 1903, by the United States Weather Bureau, by which it is maintained. It is located at Remine's bridge, about 3 miles downstream from Boonton. The gage is a vertical 2 by 12 inch board spiked to the face of the right abutment at its downstream end. It reads from 0 to 9 feet, and is graduated with copper staples. The bench mark is a square chiseled on the top of the upstream end of the right abutment. Its elevation above the gage datum is 9.14 feet. The gage reader for the Weather Bureau is Mrs. L. A. Van Derhoff. Discharge measurements are made from the downstream side of the single-span highway bridge, to which the gage is attached. The initial point for soundings is the face of the right abutment. The channel is straight for 300 feet above and below the station and the current is sluggish. Both banks are low, but will overflow only at very high water. The right bank is without trees; the left bank is wooded. The bed of the stream is composed of gravel with a few bowlders. There is a timber dam about 1 mile above the station. This station was discontinued February 2, 1904.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurement of Rockaway River near Boonton, N. J., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
May 16	F. H. Brundage	90	142	1.68	1.25	238

Mean daily gage height, in feet, of Rockaway River near Boonton, N. J., for 1904.

Day.	Jan.	Feb.	Day.	Jan.	Feb.	Day.	Jan.	Feb.	Day.	Jan.	Feb.
1	2.00	2.50	9			17			25	4.00	
2	2.00	2.50	10			18			26	3.90	
3			11			19			27	3.60	
4			12			20			28	3.50	
5			13			21			29	2.90	
6			14			22			30	2.50	
7			15			23	3.70		31	2.50	
8			16			24	3.50				

NOTE.—River frozen during January and February.

RARITAN RIVER DRAINAGE BASIN.

Raritan River, which is the largest stream in New Jersey, excepting the Delaware, rises in the highlands at the foot of Lake Hopatcong. The total area of the drainage basin is 1,105 square miles. The highlands consist mostly of trap rock and contain a large proportion of the wooded areas of the basin. Only about 10 per cent of the total

area is forested. The area outside the highlands consists of either trap rock or red sandstone. Of the 806 square miles of drainage area above the gaging station at Bound Brook, about 150 square miles are in the cultivated part of the highlands and on the trap ridges; the remainder is mostly on the low, level, red sandstone plain.

The valley of the Raritan is populous and highly cultivated, and a large amount of water power is utilized on its various branches. Raritan River throughout almost its entire length is in two parts, namely, the North and South branches. The North Branch is considered a valuable source for a gravity water supply. The upper portion is at an elevation ranging from 750 to 1,100 feet. Both the North and South branches rise close to each other, separated only by a slight divide. The other important branch is Millstone River, which differs from the other branches, having its rise in sand hills and flowing northwesterly through a sandy soil. It has a large ground storage. This stream is better suited for power than for water supply, being very muddy at high stages. All three branches are united above Bound Brook, N. J.

The United States Geological Survey maintained gaging stations in this basin during 1904 as follows: Raritan River (South Branch) at Stanton, N. J.; Raritan River at Finderne, N. J.; Raritan River at Bound Brook, N. J.; Raritan River (North Branch) at Pluckemin, N. J.; Millstone River at Millstone, N. J.

RARITAN RIVER (SOUTH BRANCH) AT STANTON, N. J.

This station was established July 2, 1903, by E. P. Roundey. It is located at the highway bridge about 500 feet from the Lehigh Valley Railroad station at Stanton, N. J. The standard chain gage is located on the lower chord of the bridge on the downstream side. The length of the chain from the end of the weight to the marker is 14.63 feet. Bench mark No. 1 is a square chiseled on the coping of the left abutment 1½ feet from the downstream end. It is 13.37 feet above gage datum. Bench mark No. 2 is the top of the upstream corner of the right abutment. It is 13.665 feet above gage datum. Bench mark No. 3 is a nail projecting one-quarter inch from downstream side of a large sycamore tree 210 below bridge and 6 feet above the ground. Elevation 11.024 feet above gage datum. Discharge measurements are made from the downstream side of the single-span highway bridge. The initial point for soundings is the face of the right abutment. The channel is straight for 800 feet above and 400 feet below the station. The current is swift. Both banks are low and liable to overflow. The bed of the stream is composed of gravel, and there is but one channel under the bridge. The gage is read twice each day by William Wilson, the station agent.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Raritan River (South Branch) at Stanton, N. J., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
June 7	J. C. Hoyt	99	178	1.14	2.92	203
August 24	do	95	154	.98	2.77	151
November 8	H. D. Comstock	92	148	1.04	2.70	153

Mean daily gage height, in feet, of Raritan River (South Branch) at Stanton, N. J., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.24	3.90	4.98	4.68	2.88	2.72	2.25	2.62	2.24	2.58	2.81	2.89
2	4.18	3.91	4.58	4.45	2.85	2.71	2.23	2.44	2.24	2.66	2.84	2.90
3	4.09	3.91	5.85	3.58	2.81	2.72	2.19	2.28	2.24	2.58	2.80	2.88
4	4.12	3.80	5.40	3.36	2.78	2.69	2.20	2.89	2.26	2.54	2.79	2.86
5	4.16	3.74	4.65	3.28	2.71	2.72	2.21	2.61	2.21	2.56	2.80	2.86
6	4.12	3.84	4.14	3.21	2.71	2.78	2.19	2.75	2.21	2.55	2.84	2.84
7	4.18	4.50	7.70	3.20	2.71	2.86	2.62	2.62	2.29	2.51	2.84	2.80
8	3.98	4.32	5.72	3.18	2.70	2.72	3.08	2.65	2.29	2.55	2.82	2.81
9	4.10	3.98	3.70	3.45	2.70	2.86	2.98	2.68	2.30	2.54	2.80	2.87
10	4.05	3.84	3.42	3.44	2.70	2.72	3.18	2.91	2.29	2.49	2.74	2.90
11	4.08	3.78	3.29	3.24	2.64	2.49	2.98	2.79	2.26	2.51	2.80	2.96
12	4.10	3.75	3.14	3.15	2.64	2.49	2.66	2.86	2.30	3.27	2.85	2.96
13	4.10	3.71	3.14	3.11	2.61	2.58	2.95	2.79	2.30	3.04	2.84	2.98
14	4.22	3.68	3.04	3.11	2.61	2.54	2.68	2.69	3.07	2.85	2.82	3.01
15	4.25	3.58	2.92	3.08	2.88	2.38	2.48	2.69	7.78	2.79	2.80	3.03
16	4.10	3.54	3.09	2.92	2.80	2.26	2.44	2.62	5.70	2.77	2.84	3.02
17	4.08	3.50	3.16	2.91	2.65	2.13	2.31	2.51	3.84	2.69	2.84	3.06
18	3.98	3.20	3.92	2.90	2.68	2.22	2.45	2.36	3.35	2.59	2.85	3.10
19	3.80	3.28	4.48	2.82	2.84	2.25	2.36	2.31	2.96	2.47	2.88	3.12
20	3.80	3.22	4.45	2.89	2.70	2.24	2.26	3.45	2.91	2.51	2.97	3.20
21	3.88	3.12	3.56	2.84	2.64	2.29	2.19	3.19	2.81	6.34	3.10	3.19
22	4.10	9.55	3.38	2.80	2.58	2.29	2.15	2.86	2.79	5.44	3.09	3.20
23	8.92	7.35	3.62	2.79	2.55	2.25	2.25	2.99	2.72	4.02	3.05	3.22
24	4.95	6.15	3.38	2.78	2.54	2.33	2.24	2.76	2.68	3.82	3.02	3.22
25	4.46	5.96	3.28	2.77	2.62	2.25	2.56	2.71	2.64	3.71	3.02	3.21
26	4.10	5.45	3.32	2.78	2.59	2.20	2.56	2.72	2.62	3.69	3.04	3.25
27	4.02	4.98	3.25	3.20	2.59	2.31	2.51	2.60	2.64	3.46	2.99	3.20
28	3.98	5.85	3.16	3.34	2.62	2.21	2.51	2.52	2.69	3.31	2.92	3.24
29	3.89	5.26	3.07	3.05	2.54	3.42	2.32	2.30	2.71	3.12	2.98	3.21
30	3.95	.....	3.01	2.91	2.47	2.60	2.41	2.31	2.69	2.94	2.91	3.90
31	3.94	.....	3.42	.....	3.12	.....	2.29	2.29	.....	2.81	.....	3.70

NOTE.—River frozen from January 1 to March 3, when ice went out. Thickness of ice varied from 2 to 12 inches. March 7, highest record 11.04. River frozen December 8 to 29. Thickness of ice one-fourth to 6½ inches. During the frozen periods the gage heights were taken to the surface of the ice.

Rating table for Raritan River (South Branch) at Stanton, N. J., from July 2, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.10	42	2.90	194	3.70	505	4.40	840
2.20	56	3.00	226	3.80	550	4.50	890
2.30	71	3.10	260	3.90	596	4.60	940
2.40	87	3.20	296	4.00	643	4.70	990
2.50	104	3.30	335	4.10	691	4.80	1,040
2.60	122	3.40	376	4.20	740	4.90	1,090
2.70	142	3.50	418	4.30	790	5.00	1,140
2.80	166	3.60	461				

The above table is applicable only for open-channel conditions. It is based upon 8 discharge measurements made during 1903 and 1904. It is well defined between gage heights 2.7 feet and 4.4 feet. The table has been extended beyond these limits. Above gage height 4.4 feet the rating curve is a tangent, the difference being 50 per tenth. The curve is very uncertain above gage height 5 feet.

Estimated monthly discharge of Raritan River (South Branch) at Stanton, N. J., for 1904.

Month.	Discharge in second-feet.			Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.		Maximum.	Minimum.	Mean.
January [a]	.....	.....	.....	July	289	49	108
February [a]	.....	.....	.....	August	397	68	146
March	2,490	200	629	September	2,530	58	263
April	980	159	302	October	1,810	99	308
May	267	99	143	November	260	152	192
June	384	46	113	December [a]	.....	.....	.....

[a] River frozen from January 1 to March 3 and from December 8–29, inclusive.

RARITAN RIVER AT FINDERNE, N. J.

This station was established June 27, 1903, by E. P. Roundey. It is located at the highway bridge, one-fourth mile from the New Jersey Central Railway station at Finderne, N. J. The standard chain gage is located on the downstream side of the right-hand truss on the lower chord. The length of the chain from the end of the weight to the end of the ring is 19.56 feet. Bench mark No. 1 is a cross chiseled on the coping of the downstream wing wall of the right abutment. Its elevation is 20.11 feet above gage datum. Bench mark No. 2 is the top of the outside connection plate near the zero of the gage scale. Its elevation is 20.14 feet above gage datum. The elevation of the top of the gage pulley is 19.21 feet above gage datum. Discharge measurements are made from the upstream side of the 2-span highway bridge. The initial point for soundings is the face of the right abut-

ment. The channel is straight for 300 feet above and 800 feet below the station. The current is swift. The right bank is low, wooded, and liable to overflow. The left bank will overflow only at extreme high water. The bed of the stream is composed of gravel. The channel is broken by the center pier of the 2-span bridge. The gage is read twice each day by Harry Siegel.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Raritan River at Finderne, N. J., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 11	F. H. Tillinghast	196	322	3.35	4.80	1,080
May 12	F. H. Brundage	168	203	2.17	4.04	440
June 6	J. C. Hoyt	160	237	2.45	4.20	580
July 30	do	155	186	1.84	3.92	343
November 10	H. D. Comstock	163	210	1.98	4.10	416

Mean daily gage height, in feet, of Raritan River at Finderne, N. J., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	[a]4.75	[a]4.75	4.75	7.98	4.38	4.18	3.80	3.88	3.90	3.95	4.20	3.95
2	[a]4.85	[a]6.30	4.70	7.35	4.55	3.90	3.88	4.33	3.83	3.90	4.20	3.90
3	4.50	[a]6.15	4.90	5.08	4.35	4.02	3.63	4.10	3.85	3.98	4.12	4.00
4	4.90	[a]5.55	6.18	4.98	4.20	3.90	3.60	4.00	3.60	3.97	4.10	3.95
5	5.28	[a]5.08	5.20	4.80	4.20	3.92	3.62	4.25	3.65	3.95	4.10	3.95
6	5.55	4.90	4.62	4.58	4.15	4.18	3.63	5.30	3.68	3.92	4.10	4.00
7	5.15	5.40	7.55	4.68	4.10	4.32	3.68	4.20	3.65	3.88	4.28	3.90
8	5.05	6.90	11.05	4.65	4.00	4.15	5.20	4.13	3.72	3.85	4.02	4.00
9	5.05	5.05	5.85	4.82	4.00	4.35	4.45	4.00	3.65	3.80	4.02	3.85
10	5.05	4.35	4.90	5.30	4.02	4.15	3.95	5.62	3.68	3.92	4.00	3.82
11	5.10	4.35	4.80	4.80	4.02	4.00	4.20	7.25	3.65	3.92	4.08	3.85
12	5.10	4.15	4.65	4.65	4.00	3.85	3.95	4.60	3.65	5.85	4.10	3.82
13	5.00	4.10	4.40	4.52	4.92	3.85	4.08	4.25	3.65	4.85	4.48	4.10
14	7.98	4.10	4.45	4.35	4.88	3.80	3.88	4.85	3.65	4.35	7.62	4.20
15	6.88	4.10	4.45	4.35	3.70	3.70	3.75	4.32	14.90	4.25	5.00	4.18
16	7.10	4.00	5.05	4.32	4.10	3.65	3.60	4.12	6.88	4.12	4.78	4.22
17	6.68	4.30	4.55	4.20	3.95	3.62	3.52	4.05	5.15	4.00	4.92	4.20
18	7.50	4.42	4.60	4.20	3.95	3.58	3.62	3.90	4.78	4.02	4.90	4.10
19	7.20	4.75	5.30	4.15	3.97	3.55	3.80	3.98	4.65	3.93	4.40	4.10
20	7.20	4.90	4.95	4.15	4.25	3.60	3.70	6.98	4.42	3.88	4.30	4.00
21	7.20	4.75	4.90	4.10	4.08	3.62	3.60	5.75	4.32	8.38	4.30	4.05
22	5.65	[a]12.72	5.00	4.30	3.92	3.65	3.70	4.63	4.20	8.30	4.30	4.00
23	[a]12.70	7.62	5.45	4.00	3.85	3.60	3.68	4.40	4.30	5.30	4.30	4.20
24	7.68	5.58	5.08	4.05	3.92	3.60	3.55	4.25	4.12	4.95	4.20	4.20
25	5.00	5.65	4.92	4.10	3.82	3.52	3.65	4.20	4.10	4.70	4.15	4.20
26	4.90	4.82	5.07	4.30	3.85	3.48	3.78	4.05	3.98	4.68	4.10	4.20
27	4.45	4.45	5.10	4.90	3.72	3.55	3.65	4.03	3.97	4.50	4.00	4.80
28	4.35	4.78	4.95	5.45	3.80	3.55	3.85	4.00	4.00	4.30	3.88	8.25
29	4.70	5.65	4.85	4.80	3.62	3.60	5.05	3.95	4.00	4.30	3.85	7.30
30	[a]6.00	.....	4.75	4.62	3.60	3.98	3.98	3.88	3.98	4.18	4.50	6.92
31	[a]5.00	.....	4.95	.....	4.22	.....	3.80	3.90	.....	4.18	.....	6.42

[a] Ice gorge causes water to rise.

NOTE.—Highest reading September 15, 15.30; October 21, 12.65.

Rating table for Raritan River at Finderne, N. J., from June 27, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.50	125	5.00	1,255	6.40	2,825	8.60	5,650
3.60	171	5.10	1,355	6.50	2,945	8.80	5,930
3.70	219	5.20	1,460	6.60	3,065	9.00	6,210
3.80	272	5.30	1,565	6.70	3,190	9.20	6,500
3.90	330	5.40	1,675	6.80	3,315	9.40	6,800
4.00	393	5.50	1,785	6.90	3,440	9.60	7,100
4.10	461	5.60	1,895	7.00	3,565	9.80	7,410
4.20	534	5.70	2,005	7.20	3,815	10.00	7,730
4.30	612	5.80	2,120	7.40	4,065	10.50	8,580
4.40	695	5.90	2,235	7.60	4,325	11.00	9,430
4.50	783	6.00	2,350	7.80	4,585	11.50	10,280
4.60	875	6.10	2,465	8.00	4,845	12.00	11,130
4.70	969	6.20	2,585	8.20	5,110	12.50	11,980
4.80	1,064	6.30	2,705	8.40	5,380	13.00	12,830
4.90	1,159						

The above table is applicable only for open-channel conditions. It is based upon 12 discharge measurements made during 1903 and 1904. It is fairly well defined between gage heights 3.90 feet and 10.50 feet. The table has been extended beyond these limits. Above gage height 10 feet the rating curve is a tangent, the difference being 170 per tenth.

Estimated monthly discharge of Raritan River at Finderne, N. J., for 1904.

Month.	Discharge in second-feet.			Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.		Maximum.	Minimum.	Mean.
March	9,515	695	1,580	August	3,878	318	856
April	4,819	393	1,081	September	16,060	171	1,043
May	1,178	171	460	October	5,353	272	920
June	654	116	296	November	4,221	301	723
July	1,460	134	343	December	5,178	284	886

RARITAN RIVER AT BOUND BROOK, N. J.

This station was established September 12, 1903, by E. P. Roundey. It is located at the highway bridge just back of the Lehigh Valley Railway station at Bound Brook, N. J. The original gage consisted of a vertical 1¼ by 6 inch cypress board 12 feet long bolted to the upstream wing wall of the right abutment. It was carried away by the ice January 23, 1904. On February 2, 1904, a standard chain gage was bolted to the upstream side of the bridge 240 feet from the right abutment. The length of the chain from the end of the weight to the marker is 23.48 feet. Bench mark No. 1 is a square chiseled on top of the upstream wing wall of the right abutment. Its elevation is 19.45 feet above gage datum. Bench mark No. 2 is the top of the rail 2 feet beyond the pulley end of the gage. Its elevation is 23.77 feet above gage datum. Bench mark No. 3 is a point on the guard rail of the bridge 225 feet from the initial point for soundings. Its elevation is 20.75 feet above gage datum. Discharge measurements are made from the upstream side of the 3-span highway bridge. The initial point for soundings is the face of the right abutment. The channel is straight for 500 feet above and below the station, and the current has a moderate velocity. Both banks are high, subject to overflow only at very high stages, and are without trees. The bed of the stream is composed of gravel. The gage is read twice each day by Joseph K. Tantum.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Raritan River at Bound Brook, N. J., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 11	F. H. Tillinghast	403	1,234	1.43	2.12	1,765
May 11	F. H. Brundage	404	1,006	.66	1.44	668
June 6	J. C. Hoyt	381	1,084	.81	1.55	879
July 30	do	378	1,016	.48	1.48	490
November 10	H. D. Comstock	384	1,052	.67	1.52	703

Mean daily gage height, in feet, of Raritan River at Bound Brook, N. J., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.80	(a)	2.25	4.00	.....	1.70	1.70	1.40	1.35	1.45	1.60	1.55
2	1.80	2.10	2.40	4.00	.....	1.70	1.70	1.75	1.40	1.40	1.55	1.45
3	1.80	1.85	2.35	2.70	.....	1.60	1.60	1.70	1.40	1.40	1.50	1.40
4	1.60	1.70	2.95	2.20	.....	1.50	1.50	1.55	1.40	1.40	1.50	1.40
5	1.50	1.60	1.90	2.10	.....	1.40	1.60	2.85	1.30	1.35	1.50	1.35
6	1.50	1.60	1.60	1.90	.....	1.55	1.60	3.40	1.30	1.30	1.50	1.35
7	1.50	1.85	3.85	2.00	.....	1.55	1.95	2.20	1.30	1.30	1.50	1.40
8	1.50	4.10	8.60	1.95	1.40	1.80	2.55	1.90	1.30	1.30	1.50	1.40
9	1.50	3.45	3.60	2.10	1.40	2.00	1.90	1.70	1.30	1.30	1.50	1.40
10	1.50	3.15	2.35	2.60	1.40	1.65	1.60	3.20	1.30	1.30	1.50	1.40
11	1.50	2.85	1.95	2.15	1.40	1.50	1.55	4.60	1.30	1.30	1.65	1.40
12	1.50	2.10	1.75	1.95	1.35	1.40	1.55	2.65	1.30	3.30	1.80	1.40
13	1.50	1.80	1.65	1.85	1.30	1.40	1.50	2.40	1.30	3.30	1.75	1.35
14	3.30	1.65	1.50	1.70	1.35	1.40	1.45	2.15	1.30	2.20	4.25	1.30
15	2.95	1.75	1.65	1.60	1.40	1.40	1.40	2.00	c10.10	1.80	2.95	1.40
16	2.40	1.65	1.80	1.60	1.45	1.35	1.40	1.75	5.45	1.70	2.40	1.40
17	2.30	1.65	1.80	1.60	1.40	1.30	1.40	1.65	3.70	1.60	2.15	1.30
18	2.30	1.65	1.80	1.60	1.40	1.30	1.35	1.55	2.35	1.55	1.95	1.35
19	2.20	1.60	2.90	1.50	1.30	1.30	1.40	1.45	2.15	1.55	1.90	1.30
20	2.10	1.60	2.65	1.50	1.45	1.25	1.35	4.50	1.90	1.45	1.85	1.30
21	2.00	1.50	2.35	1.45	1.50	1.20	1.25	4.70	1.75	4.35	1.70	1.30
22	2.00	b9.46	2.60	1.40	1.40	1.20	1.20	3.40	1.70	6.35	1.70	1.30
23	d7.90	5.25	2.80	1.40	1.30	1.20	1.25	2.55	1.60	3.25	1.65	1.30
24	(e)	4.25	2.40	1.40	1.25	1.15	1.30	2.05	1.60	2.60	1.60	1.40
25	(e)	2.65	2.10	1.40	1.20	1.10	1.25	1.80	1.60	2.30	1.60	1.60
26	(e)	2.30	2.45	1.40	1.20	1.15	1.25	1.65	1.60	2.05	1.60	2.10
27	(e)	2.05	2.50	2.45	1.20	1.15	1.20	1.60	1.60	1.95	1.55	1.80
28	(e)	2.40	1.90	.....	1.20	1.25	1.40	1.50	1.60	1.75	1.50	3.85
29	(e)	3.15	1.75	.....	1.20	1.50	2.15	1.45	1.50	1.70	1.45	3.90
30	(e)	.....	1.70	.....	1.20	1.75	1.40	1.40	1.45	1.70	1.60	3.15
31	(e)	.....	1.70	.....	1.65	.....	1.35	1.40	.....	1.60	.....	2.90

a River frozen except under gage.
b Ice gone out; river clear; highest reading 11.2 feet.
c Highest gage reading 11.7 during flood.
d Ice jam in morning; river clear in evening.
e Gage carried out by ice.

NOTE.—River frozen from January 1 to February 22. Thickness of ice varied from 2 to 12 inches. Gage height to surface of ice.

RARITAN RIVER (NORTH BRANCH) NEAR PLUCKEMIN, N. J.

This station was established September 9, 1903, by E. P. Roundey. It is located at the second bridge below Far Hills, N. J., on the road to Somerville, N. J., about 2 miles from Far Hills. The gage is a vertical 1¼ by 6 inch cypress board spiked to the upstream wing wall of the right abutment, reading from 0 to 10 feet. The gage is read twice each day by Thomas Moore. Discharge measurements are made from the single-span wooden highway bridge on the downstream side. The initial point for soundings is the face of the right abutment at its downstream end. The channel is straight for 400 feet above and 300 feet below the bridge. A small rift occurs in the channel about 200 feet above the bridge. The current is sluggish. Both banks are low and liable to overflow. The bed of the stream is composed of gravel. There is but one channel under the bridge. The bench mark is a

square chiseled on the top of the upstream wing wall of the right abutment. Its elevation is 10.38 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Raritan River (North Branch) near Pluckemin, N. J., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
May 12	F. H. Brundage	55	160	0.35	1.51	56
November 9	H. D. Comstock	55	172	.37	1.70	63

Mean daily gage height, in feet, of Raritan River (North Branch) near Pluckemin, N. J., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.50	3.00	2.30	2.85	2.00	2.30	1.65	1.95	1.40	1.80	1.80	1.95
2	2.50	3.20	2.80	2.50	2.10	2.30	1.40	1.70	1.40	1.70	1.80	1.75
3	2.50	3.20	2.60	2.30	1.80	2.35	1.40	1.52	1.40	1.60	1.80	1.60
4	2.50	3.20	2.30	2.05	1.80	2.10	1.40	2.65	1.40	1.60	1.80	1.50
5	2.50	3.20	1.90	2.00	1.70	2.15	1.30	2.05	1.40	1.60	1.80	1.50
6	2.50	3.20	1.90	2.00	1.70	1.65	1.30	1.70	1.40	1.60	1.80	1.50
7	2.50	3.45	5.25	2.00	1.55	1.90	2.00	1.50	1.40	1.50	1.75	1.70
8	2.50	3.70	3.00	2.00	1.50	1.50	2.80	1.50	1.40	1.50	1.70	1.70
9	2.50	3.30	2.45	2.10	1.50	2.05	1.65	1.50	1.40	1.85	1.70	1.70
10	2.50	3.20	2.25	2.10	1.55	1.70	2.00	2.80	1.40	1.65	1.70	1.70
11	2.50	3.20	2.20	2.10	1.60	1.58	1.70	2.65	1.40	2.80	1.80	1.70
12	2.50	3.20	2.08	2.20	1.55	1.48	1.75	2.15	1.40	1.85	1.70	1.70
13	2.65	3.20	1.95	2.10	1.50	1.40	1.70	1.90	1.40	1.70	2.85	1.70
14	3.00	3.20	1.80	2.05	1.50	1.40	1.40	1.83	3.55	1.70	2.50	1.70
15	2.70	2.80	1.80	1.90	1.60	1.40	1.50	1.68	(a)	1.70	2.18	1.70
16	2.70	2.80	1.80	1.90	1.70	1.40	1.30	1.60	.....	1.70	2.10	1.75
17	2.70	2.80	1.80	1.80	1.60	1.40	1.30	1.58	.....	1.60	2.00	1.95
18	2.70	2.80	2.00	1.80	1.60	1.35	1.65	1.50	3.00	1.60	2.00	2.30
19	2.70	2.80	2.00	1.70	1.80	1.30	1.50	4.40	2.90	1.60	2.00	2.30
20	2.70	2.80	2.10	1.70	1.90	1.30	1.35	3.00	2.60	1.52	2.95	2.30
21	2.70	2.80	2.10	1.70	1.60	1.40	1.30	1.90	2.50	4.55	2.90	2.30
22	2.75	6.15	2.10	1.70	1.52	1.40	1.30	1.78	2.40	2.80	2.88	2.30
23	b 6.26	3.55	2.10	1.70	1.50	1.40	1.30	1.70	2.30	2.55	2.80	2.30
24	4.70	4.25	2.10	1.70	1.50	1.40	1.45	1.63	2.30	2.25	2.78	2.30
25	2.90	3.95	2.10	1.70	1.50	1.30	1.65	1.60	2.30	2.05	2.70	2.30
26	2.85	3.52	2.15	1.70	1.50	1.30	1.60	1.60	2.30	1.95	2.70	2.30
27	3.00	3.50	2.15	2.25	1.40	1.28	1.30	1.60	2.20	1.90	2.70	2.35
28	3.00	3.25	2.05	2.15	1.30	1.20	1.65	1.55	2.20	1.90	2.55	2.55
29	3.00	2.55	1.80	2.00	1.30	1.65	2.20	1.48	1.90	1.90	2.35	2.75
30	3.00	.....	1.82	2.00	1.90	1.65	1.90	1.43	1.80	1.90	2.15	2.50
31	3.00	.....	2.45	.....	2.38	.....	2.00	1.40	.....	1.88	.....	2.50

a Gage washed away on 14th; put up again on 18th.
b Ice went out; greatest height, 6.8. River frozen again the 24th.

NOTE.—River frozen from January 1 to March 1, when ice went out. Thickness of ice varied from 6 to 12 inches. River frozen December 8–31. Gage heights to surface of ice.

MILLSTONE RIVER AT MILLSTONE, N. J.

This station was established June 26, 1903, by E. P. Roundey. It is located at a highway bridge near the blacksmith shop in the village of Millstone, N. J. The gage is a vertical 1¼ by 6-inch cypress board, spiked to the left abutment of the bridge on the downstream side. It reads from 0 to 10 feet, and is graduated with galvanized-iron staples. The bench mark is a cross chiseled on the coping near the end of the downstream wing wall of the left abutment. Its elevation is 11.11 feet above the zero of the gage. The gage is read twice each day by E. H. Wyckoff, the blacksmith. Discharge measurements are made from the upstream side of the single-span highway bridge, to which the gage is attached. The bridge has a span of 93 feet and is located about 1 mile above a dam. The gage heights may be influenced by this dam and also by backwater from Raritan River. The initial point for soundings is the face of the left abutment. The channel is straight for 500 feet above and 100 feet below the station. The current is sluggish at low water. Both banks are low, wooded, and liable to overflow. At extreme high water the right bank overflows for a considerable distance. The bed of the stream is composed of gravel. This station was discontinued December 31, 1904.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Millstone River at Millstone, N. J., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 11	F. H. Tillinghast	93	372	1.60	1.19	596
June 26	J. C. Hoyt	93	293	.86	.27	251
July 30	do	93	268	.44	.05	118
November 10	H. D. Comstock	93	352	.70	.84	247

Mean daily gage height, in feet, of Millstone River at Millstone, N. J., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.55	0.58	1.85	3.12	1.02	0.68	−0.04	0.15	0.25	(a)	0.80	0.85
2	.35	.50	2.22	3.65	.68	1.38	− .01	.52	.22	(a)	.87	.75
3	.30	.50	1.72	2.25	.60	.75	− .04	.50	.25	(a)	.85	.75
4	.30	.50	2.02	1.38	.50	.50	− .08	.52	.25	(a)	.87	.70
5	.50	.50	1.08	1.08	.35	.40	− .01	1.15	.15	(a)	.85	.65
6	.50	.50	.42	.88	.28	.30	− .02	.85	.18	0.58	.87	.60
7	.50	1.80	2.45	.92	.25	.72	.08	1.88	.18	.60	.75	.65
8	.50	3.72	6.20	.88	.20	1.08	.48	1.60	.15	.55	.78	.65
9	.50	1.85	4.02	1.08	.20	1.32	.45	.75	.06	.60	.87	.65
10	.50	1.15	1.88	1.60	.20	.85	.38	.65	.12	.55	.87	.65
11	.50	.75	1.08	1.20	.18	.42	.25	2.78	.20	.48	1.25	.65
12	.50	.35	.75	1.02	.20	.22	.18	2.78	.04	3.25	1.30	.65
13	.52	.28	.62	.82	.10	.10	.40	2.58	.01	4.65	1.52	.65
14	2.10	.25	.52	.62	.12	.05	.40	2.60	.15	1.98	4.27	.65
15	1.70	.18	.40	.52	.30	.02	.25	1.22	7.32	1.40	3.32	.65
16	1.25	.20	.55	.52	.18	.05	.20	.82	7.42	1.20	2.32	.65
17	1.05	.20	.80	.38	.02	.05	.10	.62	5.02	.98	1.80	.65
18	.60	.20	.85	.32	−.10	.02	.12	.40	2.20	.92	1.40	.65
19	.56	.20	2.12	.35	.12	−.02	.08	.30	1.30	.85	1.22	.65
20	.50	.20	1.62	.30	.20	−.16	.10	6.20	.95	.85	1.15	.65
21	.50	.20	1.18	.28	.22	.12	.10	6.75	.72	4.10	1.10	.65
22	.50	7.16	1.40	.20	.30	.02	− .03	5.15	.55	6.40	.98	.65
23	[b]6.88	6.90	1.65	.20	.10	.05	− .02	2.62	.48	3.55	.92	.65
24	6.20	[c]5.02	1.38	.10	.05	.00	− .03	1.90	.45	2.30	.92	.72
25	4.02	2.60	1.12	.15	.05	.00	.02	.88	.42	1.62	.90	.95
26	1.78	2.05	1.38	.18	.10	.03	− .07	.70	.25	1.32	.85	.90
27	3.02	.68	1.38	1.80	.02	.10	.02	.60	.32	1.25	.78	1.25
28	2.10	1.52	.92	2.68	[f]−.05	.01	.35	.52	.30	1.07	.68	4.00
29	1.45	2.00	.68	2.08	−.04	−.02	.20	.42	(a)	1.00	.68	2.90
30	.98	.....	.65	1.52	.01	−.08	.10	.38	(a)	.92	.88	2.35
31	.70	.....	1.05	.....	.50	.....	.10	.22	.....	.87	.....	2.02

[a] Below gage; drawn off to repair dam. [b] Caused by ice jam. [c] Ice gone out of river.

NOTE.—River frozen January 1 to February 23; also December 11 to 31. Ice 3 to 6 inches thick. Gage heights to surface of ice.

DELAWARE RIVER DRAINAGE BASIN.

Delaware River rises on the slope of Mine Mountain, near the southwestern line of Schoharie County, New York, flows southwesterly across central Delaware County to Deposit, where it is joined by Oquaga Creek, a large tributary draining eastern Broome County. The upper drainage area is relatively long and narrow, with numerous short lateral tributaries. It is rugged and to a considerable extent wooded. There are low water-power dams near Hamden and Delhi. At Deposit the stream turns abruptly to the southeast, forming the boundary line between New York and Pennsylvania, until Port Jervis is reached. Here it encounters the foot of the Shawangunk Range, and its direction of flow is again turned to the southwest. Below Port Jervis the Delaware forms the division between Pennsylvania and New Jersey, and ultimately empties into Delaware Bay below Philadelphia.

Above Hancock the main stream is known as the West Branch of Delaware River, to distinguish it from the smaller East or Pepacton Branch.

The West Branch of the Delaware is sometimes called the Mohawk. It should not be confused with Mohawk River, a tributary of Hudson River. The East Branch of the Delaware flows parallel to the West Branch across southern Delaware County, but its drainage area is broader and its tributaries longer and more branching than those of the West Branch. Many of the tributaries head in small lakes and ponds.

From Hancock to Port Jervis, a distance by river of 76 miles, the Delaware flows in a broad, shallow channel with numerous slight rifts and a relatively rapid current. Several large tributaries enter in this section of the stream, notably Mongaup and Callicoon creeks and Neversink River from the New York side, and the Lackawaxen River from Pennsylvania.

The drainage area of Delaware River above Port Jervis lies about four-fifths in New York and one-fifth in Pennsylvania.

Neversink River rises in southwestern Ulster County, two branches uniting to form the main stream near Sullivan County line. The stream then flows southerly, crossing eastern Sullivan County, and enters Delaware River at Port Jervis. Its fall is rapid and often precipitous, and its drainage basin contains numerous small lakes.

Measurements of flow of Delaware River were made during the latter half of June, 1891, by Prof. Dwight Porter and students at Delaware Watergap, Pa. The results show a flow of from 2,000 to 2,200 second-feet. This was said to be the lowest June stage for five years. Measurements were made during the drought of 1895 by Prof. L. M. Haupt at Point Pleasant, Pa., near the intake of the Delaware and Raritan Canal feeder. The discharge above the bridge was 1,657 second-feet and below the bridge 1,328 second-feet. Delaware River was measured by E. G. Paul, June 4, 1899, at Martins Creek, Pa., 7 miles above the mouth of Lehigh River, and a discharge of 2,724 second-feet was found.

Stations were maintained in this basin during 1904 by the United States Geological Survey as follows: Delaware River (West Branch) at Hancock, N. Y.; Delaware River (East Branch) at Hancock, N. Y.; Delaware River at Lambertville, N. J.; Lehigh River at South Bethlehem, Pa.; Musconetcong River near Bloomsbury, N. J.

Aside from these stations, measurements have been made for several years by John E. Codman, hydrographer of the water department of the city of Philadelphia. The stations maintained by Mr. Codman are located on the following streams, all in the vicinity of Philadelphia: Perkiomen, Tohickon, and Neshaminy creeks, and Schuylkill River.

DELAWARE RIVER (WEST BRANCH) AT HANCOCK, N. Y.

This station was established October 15, 1902, by P. M. Churchill, assisted by C. C. Covert. It is located about one-half mile southwest of the Erie Railroad station at Hancock, N. Y., and about 1 mile above the junction of the East and West branches of the Delaware. The original wire gage was attached to the upstream side of the bridge. It was replaced July 20, 1903, by a standard chain gage, which was installed by F. H. Tillinghast. The location and the gage datum were not changed. The length of the chain from the end of the weight to the marker is 30.44 feet. The gage is read twice each day by David Pulver, the collector of tolls at the bridge. Discharge measurements are made from the downstream side of the bridge at which the gage is located. The bridge has a single span of 235 feet. The initial point for soundings is the top of the face of the left abutment on the downstream side. The bridge floor is marked at intervals of 5 feet with black paint. The channel is straight for 400 feet above and for 800 feet below the bridge. The current is swift. Both banks are high and rocky and are not subject to overflow. The bed of the stream is composed of earth and cobblestones. The bench mark is a circular chisel draft on the upstream corner of the left abutment. Its elevation is 24.25 feet above gage datum. The elevation of the top of the pulley is 30.54 feet above gage datum.

The observations at this station during 1904 have been made under the direction of R. E. Horton, district hydrographer.

Discharge measurements of Delaware River (West Branch) at Hancock, N. Y., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Sq. feet.	*Feet per sec.*	*Feet.*	*Second-feet.*
July 15.....	C. C. Covert.....	326	0.55	3.05	180
September 11..	Covert and Swancott....	408	.92	3.39	375

Mean daily gage height, in feet, of Delaware River (West Branch) at Hancock, N. Y., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.82	7.47	9.71	5.79	4.98	3.49	3.26	3.65	3.45	4.35	3.85	3.90
2	5.87	8.52	9.91	6.59	4.76	3.32	3.11	4.15	3.50	4.10	3.75	3.55
3	5.37	7.97	10.06	5.64	4.56	3.39	2.94	4.90	3.55	3.90	3.75	3.35
4	5.17	7.67	11.81	5.21	4.56	3.42	3.11	4.50	4.15	3.80	3.65	3.35
5	4.57	7.42	12.41	5.13	4.27	3.81	3.11	4.10	4.20	3.75	3.55	3.30
6	5.42	7.07	11.44	5.13	4.27	3.71	3.21	5.50	3.90	3.55	3.55	3.35
7	5.77	7.82	11.39	5.46	4.02	3.46	3.01	4.20	3.70	3.45	3.60	3.45
8	5.77	14.43	11.66	5.76	3.97	3.66	3.06	3.90	3.50	3.35	3.50	3.25
9	5.72	13.26	11.81	5.83	3.92	4.41	3.08	3.75	3.40	3.45	3.40	3.80
10	5.22	11.96	10.04	6.23	3.67	4.11	3.11	3.90	3.35	3.50	3.45	4.25
11	5.42	11.86	8.69	5.73	3.57	3.96	3.06	4.35	3.40	3.50	3.40	4.75
12	5.32	11.61	8.27	5.33	3.42	3.74	3.14	4.12	3.35	3.75	3.45	4.70
13	5.12	11.81	6.91	5.03	3.57	3.48	3.06	3.80	3.10	3.90	3.40	4.70
14	5.07	10.96	6.34	4.78	3.37	3.46	3.30	3.70	3.20	4.65	3.60	4.60
15	4.42	11.01	6.14	4.53	4.27	3.46	3.10	3.80	4.40	4.40	3.40	4.50
16	4.87	10.51	5.71	4.40	4.12	3.61	4.50	3.85	4.10	4.25	3.55	4.60
17	5.02	10.06	5.81	4.43	4.12	3.68	3.80	3.55	3.55	4.05	3.35	4.25
18	4.97	10.06	5.89	4.28	4.17	3.31	3.65	3.60	3.55	3.90	3.30	4.65
19	4.67	10.01	5.87	4.03	3.97	3.26	3.60	3.60	3.55	3.90	3.35	4.45
20	4.52	10.06	5.84	3.98	4.57	3.14	3.40	4.10	3.35	3.80	3.45	4.55
21	4.72	10.06	6.09	4.03	4.32	3.21	3.30	4.75	3.15	5.30	3.90	4.40
22	4.87	10.31	5.69	4.08	4.19	3.01	3.20	4.35	3.10	7.50	4.50	4.25
23	6.32	11.11	7.81	3.98	3.92	3.06	3.10	5.40	3.10	5.96	4.40	4.45
24	7.32	11.76	9.42	3.93	4.07	3.11	3.05	4.70	3.20	5.35	4.45	4.65
25	5.62	10.56	8.84	3.98	3.77	3.16	3.00	4.85	5.00	5.00	4.25	4.85
26	5.12	10.46	13.05	4.03	3.87	3.16	3.35	4.25	4.40	4.85	4.10	4.45
27	6.27	10.01	7.54	4.16	3.62	2.94	4.15	4.05	4.50	4.55	3.95	4.95
28	8.62	9.91	6.04	5.06	3.52	2.71	3.60	3.88	4.45	4.15	3.60	7.30
29	8.32	10.06	5.39	5.20	3.37	3.06	4.20	3.72	3.90	4.15	3.55	5.75
30	8.32	.....	5.24	5.10	3.37	2.84	3.90	3.80	4.65	3.95	4.05	5.05
31	7.92	.....	5.04	.....	3.47	.....	3.80	3.50	.....	3.95	.....	4.60

NOTE.—Ice conditions January 1 to March 7; also December 9 to 27. Gage heights to surface of ice.

DELAWARE RIVER (EAST BRANCH) AT HANCOCK, N. Y.

This station was established October 14, 1902, by P. M. Churchill and C. C. Covert. It is located at the highway bridge one-half mile southeast of the Erie Railroad station at Hancock, N. Y., and 1 mile above the junction with the West Branch of Delaware River. The Erie Railroad bridge is just below the station. The standard chain gage with inclosed scale is attached to the lower chord of the second span from the left end of the bridge on the upstream side. It was installed to replace the old wire gage July 21, 1903, by F. H. Tillinghast. The gage datum was not changed. The length of the chain from the end of the weight to the marker is 32.43 feet. The gage is read twice each day by D. B. Van Etten. Discharge measurements are made from the downstream side of the 5-span iron highway bridge to which the gage is attached. The bridge has a total span of 425.5 feet between abutments. The initial point for soundings is the face of the right abutment at the top. The channel is straight for 600 feet above and for 300 feet below the station. The current is swift. Both banks are of medium height, and are not subject to overflow. The bed of the stream is composed of rocks and gravel and is not subject to change. There are three channels at low water and five channels at high water. The bench mark is a circular chisel draft on the top of the left abutment on the downstream side. It is marked "B. M." Its elevation is 27.93 feet above gage datum. The elevation of the top of the gage pulley is 32.40 feet above gage datum. During low water the elevation of the water surface at the station is lower than the water surface at the station on the West Branch of the Delaware, but there is no danger of the gage heights being affected by backwater from the West Branch, as there is considerable fall between the gaging station and the junction of the branches.

The observations at this station during 1904 have been made under the direction of R. E. Horton, district hydrographer.

Discharge measurements of Delaware River (East Branch) at Hancock, N. Y., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Sq. ft.	*Ft. per sec.*	*Feet.*	*Second-feet.*
July 14	C. C. Covert	586	0.98	3.26	578
September 11	Covert and Swancott	528	.77	3.04	408

Mean daily gage height, in feet, of Delaware River (East Branch) at Hancock, N. Y., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.67	5.32	4.71	5.64	5.28	3.47	3.28	3.75	3.28	3.85	3.80	4.45
2	4.97	4.77	4.81	6.99	4.96	3.39	3.26	3.75	3.28	3.62	3.70	4.32
3	4.32	4.62	4.96	6.24	4.73	3.37	3.08	3.98	3.22	3.55	3.62	4.12
4	4.17	4.52	4.86	5.64	4.56	3.37	2.96	3.78	3.35	3.48	3.60	4.22
5	4.17	4.47	5.51	5.33	4.42	3.38	2.95	3.58	3.32	3.40	3.52	3.90
6	4.17	4.42	5.79	5.43	4.25	3.54	2.95	3.48	3.18	3.32	3.60	4.05
7	4.35	[a]6.81	7.54	6.03	4.15	3.58	2.97	3.38	3.12	3.30	3.58	4.15
8	4.62	8.26	19.49	6.18	4.05	3.94	3.05	3.25	3.08	3.22	3.48	4.05
9	4.49	8.21	13.99	7.13	3.95	4.18	2.97	3.20	3.10	3.20	3.40	3.90
10	4.49	7.21	12.54	7.38	3.85	4.18	2.95	3.45	3.15	3.20	3.40	3.75
11	4.77	6.91	12.74	6.83	3.77	3.94	2.90	4.35	3.08	3.20	3.40	4.05
12	4.42	6.01	12.79	6.68	3.72	3.76	2.97	4.02	2.98	3.32	3.40	4.35
13	4.22	5.61	12.79	6.28	3.65	3.64	3.30	3.70	2.90	4.05	3.35	4.40
14	4.22	5.36	12.64	5.53	3.55	3.48	3.22	3.55	2.92	3.95	3.48	4.35
15	4.42	5.31	12.69	4.78	3.69	3.46	3.08	3.55	3.28	3.78	3.42	4.45
16	4.57	5.01	12.64	4.80	4.07	3.54	3.80	3.42	3.85	3.68	3.50	4.55
17	4.87	4.71	12.44	4.58	3.95	3.41	3.58	3.32	3.42	3.60	3.45	4.65
18	4.77	4.61	12.24	4.48	3.85	3.31	3.45	3.60	3.22	3.52	3.40	4.70
19	4.67	4.51	12.14	4.38	3.85	3.26	3.65	3.52	3.12	3.50	3.40	4.70
20	4.92	4.61	12.34	4.28	3.99	3.18	3.40	3.80	3.10	3.45	3.40	4.70
21	5.22	4.56	12.24	4.16	3.92	3.16	3.22	4.70	3.05	9.02	3.60	4.70
22	5.57	4.66	13.34	4.20	3.79	3.14	3.12	4.15	2.98	9.10	4.25	4.65
23	5.52	5.11	14.49	4.23	3.67	3.08	3.08	4.52	2.92	6.38	4.18	4.65
24	[b]9.32	5.01	15.74	4.10	3.72	3.06	3.05	4.18	3.00	5.50	4.15	4.55
25	10.57	4.76	15.39	4.23	3.65	3.01	3.00	3.95	3.50	5.00	4.10	5.15
26	9.32	4.61	17.04	4.23	3.57	2.98	3.18	3.88	3.60	4.75	4.02	4.85
27	10.17	4.41	9.24	4.53	3.59	2.91	3.42	3.75	3.58	4.48	3.88	5.05
28	10.12	4.61	6.49	5.13	3.55	2.88	3.35	3.58	3.48	4.28	3.75	7.10
29	9.07	4.61	5.59	5.68	3.45	2.94	5.96	3.48	3.40	4.12	4.80	5.80
30	8.07	.....	5.39	5.46	3.39	3.06	4.52	3.40	3.78	4.00	5.10	5.05
31	5.42	.....	5.19	.....	3.45	.....	4.00	3.32	.....	3.88	.....	4.80

[a] January 24–30, back water from ice jam. [b] February 7–13, back water from ice jam.

NOTE.—River frozen from January 10 to March 21; also December 11–28. Gage heights to surface of water in hole cut in ice.

DELAWARE RIVER AT LAMBERTVILLE, N. J.

This station was established at the covered toll bridge on July 23, 1897, by E. G. Paul. The datum of the chain gage was 2 feet below that of the United States Weather Bureau gage painted on the first bridge pier, and was referred to a copper bolt set in the sill of the extreme south door at the east side of the station of the Pennsylvania Railroad; elevation, 27.82 feet. This bench mark is No. 9 of the Pennsylvania Railroad and has an elevation of 72.69 feet above sea level. The bridge to which this gage was attached was carried away in the flood of October 10–11, 1903. After that date and until July 22, 1904, gage heights were read from a temporary gage on one of the piers. On the latter date a standard chain gage was attached to the new steel bridge which occupies the site of the old toll bridge and set to the same datum as the original chain gage; length of chain, 30.46 feet. At the time this gage was installed a second bench mark was established on the top of the bolt in the fifth course below the

coping on the upstream face of the left abutment; elevation, 14.82 feet. Measurements are made from the lower side of the bridge. The initial point for soundings is on the left bank. The channel above and below is straight. The current is sluggish for a short distance near the left bank. The bed is of gravel and sand and does not change. A dam, located about a mile below the station, may change slowly and thus affect in time the stage of water at the station. The gage is read twice daily by Charles H. Naylor, collector of tolls.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Delaware River at Lambertville, N. J., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
July 22	R. J. Taylor	910	3,614	0.90	2.98	3,249
November 7	E. C. Murphy	1,030	4,747	1.33	3.94	6,305

Mean daily gage height, in feet, of Delaware River at Lambertville, N. J., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	.....	5.45	3.85	3.20	3.10	3.80	3.10	3.65	4.35	4.00
2	.....	.....	.....	8.05	3.75	3.20	3.50	3.55	3.05	3.60	4.20	4.10
3	.....	(a)	(b)	7.80	3.45	3.20	3.35	3.40	3.05	3.90	4.10	4.05
4	.....	.....	.....	6.50	3.10	3.05	3.25	3.30	3.10	3.75	4.05	3.95
5	(a)	c 7.30	.....	5.30	2.95	2.90	3.10	3.55	3.05	3.55	3.95	3.90
6	.....	c 6.30	.....	4.95	2.85	2.95	3.05	3.60	3.00	3.50	4.00	3.75
7	.....	.....	5.30	4.75	2.65	3.05	3.00	3.40	3.10	3.40	3.90	3.80
8	.....	(a)	9.45	4.85	2.60	2.80	3.45	3.30	3.20	3.40	3.80	3.65
9	.....	.....	7.70	5.30	2.50	2.70	4.20	3.35	3.00	3.40	3.80	3.55
10	(a)	7.00	8.05	5.60	2.50	3.10	4.00	3.30	2.95	3.30	3.70	3.60
11	.....	8.30	6.40	5.65	2.55	3.25	3.70	4.10	3.20	3.20	3.70	(a)
12	.....	.....	5.20	5.10	2.65	3.15	3.55	3.45	2.95	3.90	3.70	.....
13	.....	(a)	4.55	4.60	2.60	2.85	3.70	3.95	2.80	3.70	3.80	.....
14	.....	.....	4.15	4.15	2.60	2.70	3.50	4.15	3.50	3.90	4.40	.....
15	(a)	7.90	3.80	3.85	2.65	2.65	3.00	3.80	6.95	4.20	4.35	.....
16	.....	.....	3.75	3.50	2.80	2.50	3.00	3.45	5.15	4.30	4.25	.....
17	.....	.....	3.45	3.35	2.80	2.40	3.00	3.25	4.75	4.05	4.20	.....
18	.....	(a)	3.40	3.05	3.05	2.30	3.05	3.15	4.60	3.90	4.10	.....
19	.....	.....	3.40	3.00	3.25	2.20	3.40	3.05	4.20	3.75	4.05	.....
20	(a)	.....	3.85	2.90	3.35	2.20	3.40	3.40	3.90	3.60	4.00	.....
21	.....	d 10.00	3.85	2.90	3.35	2.20	3.00	3.95	3.60	4.85	3.90	.....
22	.....	d 15.05	3.95	2.85	3.35	2.10	3.20	3.95	3.50	7.60	4.05	.....
23	e 5.00	d 13.50	4.25	2.70	3.20	2.00	2.80	4.30	3.35	9.15	4.40	.....
24	e 4.45	d 11.75	4.20	2.60	2.95	2.00	2.80	4.05	3.20	7.10	4.70	.....
25	e 4.30	.....	5.75	2.50	2.85	2.00	2.75	4.20	3.20	6.25	4.60	.....
26	e 5.00	.....	f 6.45	2.50	2.80	2.00	2.80	4.00	3.10	5.60	4.55	.....
27	.....	.....	f 9.75	2.80	3.20	2.80	2.95	3.65	3.10	5.20	4.45	.....
28	.....	(b)	8.30	3.15	3.50	2.80	3.45	3.55	3.75	5.00	4.30	.....
29	(a)	.....	6.20	3.60	3.35	2.80	3.40	3.40	3.70	4.80	4.20	e 7.90
30	.....	.....	5.15	3.95	2.95	2.90	3.45	3.30	3.75	4.70	4.00	9.40
31	.....	.....	4.80	.....	3.15	.....	4.10	3.20	.....	4.50	.....	5.70

a River frozen at pier. From January 1 to 23 frozen across.
b Ice jam at pier February 25 to March 7.
c Ice jam three-fourths mile below bridge is cause of rise.
d Ice jam cause of rise.
e River open.
f Upper Delaware ice cause of rise.

LEHIGH RIVER NEAR SOUTH BETHLEHEM, PA.

This station, which was established September 22, 1902, by Prof. Mansfield Merriman, of Lehigh University, is located at New Street Bridge, between Bethlehem and South Bethlehem, Pa. The standard chain gage is attached to the hand rail near the right bank on the lower side of the bridge. The length of chain from the end of the weight to the marker is 43.77 feet. The datum of the gage is referred to bench mark No. 72 of the Lehigh Valley Railroad, which is an iron pin set in the south pier of New Street Bridge; elevation, 22.32 feet. This bench mark is 232.87 feet above sea level. Discharge measurements are made from the bridge to which the gage is attached. This bridge has nine spans, but the river is confined to three, except at high stages. The right bank is high and will not overflow, but on the left bank the river overflows at high stages and joins Monocacy Creek, which is tributary to Lehigh River a few rods below the station. The initial point for soundings is the face of the pier on the right bank. The channel is straight for several hundred feet above and below the station. The bed is composed of sand and gravel, which is free from vegetation and is permanent. The velocity is fair. The gage is read once daily by Harry E. Edmonds.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Lehigh River near South Bethlehem, Pa., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
July 21	R. J. Taylor	.....	760	1.10	2.29	838
November 7	H. D. Comstock	293	923	1.38	2.69	1,276

Mean daily gage height, in feet, of Lehigh River near South Bethlehem, Pa., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.80	3.00	3.30	6.60	3.00	2.80	2.60	2.50	2.20	2.40	2.80	2.80
2	2.80	2.80	3.40	6.75	3.00	2.80	2.50	2.40	2.20	2.30	2.80	2.70
3	2.50	2.80	4.00	5.70	2.90	3.00	2.40	2.60	2.30	2.30	2.80	2.60
4	2.90	2.70	4.52	4.70	2.80	2.70	2.30	2.70	2.10	2.30	2.70	2.50
5	2.70	2.80	3.50	4.50	2.80	3.20	2.20	2.60	2.20	2.30	2.70	2.50
6	2.70	2.90	3.50	4.30	2.70	3.20	2.10	2.50	2.10	2.30	2.70	2.60
7	2.70	2.90	10.26	4.30	2.60	3.10	2.60	2.30	2.20	2.30	2.70	2.60
8	2.80	4.10	9.15	4.30	2.60	3.00	3.95	2.40	2.10	2.30	2.60	2.60
9	2.70	3.90	6.60	4.40	2.60	3.10	3.10	2.40	2.10	2.30	2.60	2.50
10	2.60	3.50	5.80	4.30	2.60	3.90	3.10	2.40	2.40	2.80	2.60	2.50
11	2.60	3.10	5.30	4.00	2.70	.....	2.90	3.00	2.20	2.30	2.60	2.50
12	2.70	3.00	4.60	3.90	2.60	.....	2.70	2.60	2.10	2.50	2.60	2.50
13	2.80	2.90	4.30	3.80	2.40	3.80	2.70	2.40	2.10	2.70	2.60	2.50
14	2.80	2.80	4.10	3.70	2.40	.....	2.55	2.40	2.35	2.70	3.20	2.40
15	2.70	2.80	4.00	3.50	.....	3.10	2.30	2.50	3.50	2.70	3.20	2.50
16	2.60	2.80	3.90	3.40	3.00	3.00	2.25	2.40	3.70	2.60	3.10	2.50
17	2.50	2.70	3.70	3.30	2.80	2.90	2.20	2.30	3.20	2.60	2.90	2.40
18	2.40	2.70	3.70	3.20	2.70	2.70	2.40	2.30	2.80	2.50	2.80	2.40
19	2.40	2.60	3.60	3.10	2.70	2.60	2.70	2.20	2.80	2.40	2.80	2.50
20	2.70	2.60	4.30	3.10	2.70	2.50	2.60	2.40	2.70	2.40	2.70	2.50
21	2.40	2.60	4.30	3.10	2.60	2.50	2.20	3.15	2.60	2.50	3.20	2.50
22	2.80	6.58	4.20	3.10	2.60	2.50	2.20	2.90	2.60	6.30	3.10	2.50
23	6.40	4.65	4.30	3.00	2.50	2.50	2.10	3.00	2.50	4.70	3.10	2.40
24	5.40	4.30	4.40	3.00	2.50	2.40	2.30	2.80	2.50	4.10	3.00	2.40
25	4.15	4.10	4.70	2.90	2.50	2.40	2.40	2.60	2.30	3.80	2.90	2.40
26	3.80	3.30	5.30	2.90	2.60	2.40	2.60	2.50	2.30	3.60	2.80	2.80
27	3.70	3.25	5.10	3.00	2.70	2.30	3.60	2.40	2.30	3.40	2.80	2.70
28	3.30	3.10	4.90	3.20	2.60	2.20	3.20	2.30	2.30	3.20	2.80	3.50
29	3.30	3.30	4.30	3.20	2.40	2.35	3.00	2.30	2.30	3.10	2.80	4.30
30	3.20	.....	4.10	3.10	2.40	2.60	2.80	2.30	2.50	3.00	2.80	3.60
31	3.10	.....	4.10	.....	2.80	.....	2.60	2.20	.....	2.90	.....	3.40

MUSCONETCONG RIVER NEAR BLOOMSBURY, N. J.

This station was established July 4, 1903, by E. P. Roundey. It is located at the first highway bridge over Musconetcong River above the village of Bloomsbury, N. J. The 1903 gage was a vertical 1¼ by 6-inch cypress board spiked to the right abutment near the downstream end. It read from 0 to 10 feet, and was graduated with galvanized-iron staples. A standard chain gage was installed at this station on April 12, 1904, by F. H. Tillinghast to the same datum as the staff gage; length of chain, 12.46 feet. The bench mark is a square chiseled on the top of the right abutment at its downstream end. Its elevation is 9.63 feet above the gage datum. Discharge measurements are made from the downstream side of the two-span highway bridge to which the gage is attached. The initial point for soundings is the end of the hand rail on the right bank. The channel is straight for 200 feet above and 100 feet below the station. The current is swift, and both banks are low and liable to overflow. The

bed of the stream is composed of gravel. The channel is broken by the central pier of the two-span bridge, and at high stages part of the water flows around the bridge. Gage readings are taken twice each day by Michael Kieffer.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Musconetcong River near Bloomsbury, N. J., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
June 7	J. C. Hoyt	64	118	1.56	1.48	184
July 23	R. J. Taylor	64	119	.80	1.14	95
August 24	J. C. Hoyt	64	100	1.07	1.22	106
November 8	H. D. Comstock	60	108	1.35	1.29	147

Mean daily gage height, in feet, of Musconetcong River near Bloomsbury, N. J., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.75	1.72	1.78	.....	1.55	1.31	1.13	1.18	1.05	1.10	1.30	1.48
2	1.68	1.60	1.80	.....	1.51	1.25	1.15	1.08	.95	1.08	1.25	1.25
3	[a]2.18	1.72	2.55	.....	1.41	1.28	1.08	1.08	.95	1.15	1.25	1.42
4	2.42	1.70	1.98	.....	1.38	1.28	1.03	1.05	1.00	1.10	1.30	1.48
5	2.20	1.68	1.82	(b)	1.33	1.28	1.03	1.90	1.02	1.12	1.28	1.25
6	2.08	1.60	1.75	.....	1.41	1.35	1.03	1.12	1.00	1.12	1.28	1.22
7	1.92	1.85	4.75	.....	1.28	1.38	1.03	1.05	1.00	1.15	1.28	1.25
8	1.68	1.95	.....	.....	1.43	1.31	1.58	1.10	.95	1.18	1.22	1.28
9	1.68	1.65	.....	.....	1.35	1.33	1.48	1.02	1.00	1.15	1.22	1.20
10	1.62	1.65	(b)	(b)	1.33	1.33	1.35	1.08	.90	1.12	1.15	1.20
11	1.60	1.62	.....	.....	1.33	1.28	1.33	1.35	.98	1.08	1.22	1.15
12	1.52	1.55	.....	1.98	1.31	1.25	1.21	1.18	1.10	1.32	1.22	1.28
13	1.62	1.52	.....	1.75	1.31	1.18	1.18	1.12	.90	1.22	1.28	1.25
14	1.82	1.50	.....	1.63	1.28	1.18	1.15	1.18	4.05	1.15	1.55	1.25
15	1.65	1.52	(b)	1.53	1.43	1.13	1.05	1.12	3.35	1.12	1.32	1.25
16	1.58	1.35	.....	1.55	1.41	1.13	1.03	1.08	2.22	1.15	1.45	1.22
17	1.55	2.62	.....	1.55	1.38	1.13	.98	1.08	1.85	1.12	1.40	1.22
18	1.50	1.85	.....	1.58	1.33	1.08	1.11	1.05	1.55	1.08	1.40	1.18
19	1.40	1.40	.....	1.75	1.35	1.08	.98	.98	1.50	1.08	1.32	1.25
20	1.38	1.45	(b)	1.38	1.43	1.11	1.11	1.20	1.32	1.12	1.32	1.22
21	1.50	1.40	.....	1.35	1.31	1.05	1.05	1.28	1.32	2.35	1.40	1.22
22	2.35	[c]5.58	.....	1.31	1.33	1.05	1.01	1.20	1.25	2.55	1.45	1.20
23	4.55	2.45	.....	1.28	1.28	.93	1.05	1.25	1.20	2.20	1.40	1.20
24	2.70	2.55	.....	1.28	1.25	1.05	1.02	1.20	1.18	1.90	1.40	1.22
25	2.30	1.98	(b)	1.33	1.21	1.11	1.12	1.12	1.18	1.60	1.35	1.20
26	2.05	1.80	.....	1.31	1.23	.93	1.12	1.05	1.20	1.52	1.40	1.22
27	1.98	1.72	.....	1.51	1.23	1.13	1.10	1.05	1.15	1.42	1.32	1.42
28	1.88	1.98	.....	1.63	1.21	1.05	1.10	1.08	1.18	1.40	1.30	1.80
29	1.82	1.78	.....	1.61	1.18	1.18	1.05	1.08	1.12	1.35	1.28	1.58
30	1.78	.....	(b)	1.53	1.13	1.18	1.12	1.02	1.18	1.35	1.40	1.52
31	1.72	.....	.....	.....	1.38	.....	1.08	1.00	.....	1.30	.....	1.45

[a] Ice gorging below. [b] Gage rod washed out. [c] Rain and melting snow causes rise.

TOHICKON CREEK AT POINT PLEASANT, PA.

Tohickon Creek drains an area of 102 square miles in Bucks County, north of Philadelphia. It flows in an easterly course, entering Delaware River about 8 miles above Lambertville, N. J. In a statement by Rudolph Hering, printed in the report of the Philadelphia water department for 1885, page 350, is given a classification of the drainage area of Tohickon Creek, from which it appears that 76 square miles is cultivated and improved and 26 square miles untillable and wooded. Measurements of the discharge of the creek are made near its mouth at Point Pleasant. Rain gages are located within the drainage basin at Quakertown, also at a point about 3 miles north of Bedminster, and near Point Pleasant.

Tables of daily discharge in second-feet, for the years 1883 to 1899, inclusive, are published in Water-Supply Paper No. 47, page 81. Daily records of gage height were not kept during 1900. The following figures of discharge for 1904 were furnished by Mr. John E. Codman, hydrographer of the Water Department of Philadelphia.

Mean daily discharge, in second-feet, of Tohickon Creek at Point Pleasant, Pa., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	128	111	247	1,494	68	358	26	27	17	46	33	38
2	162	107	357	1,215	61	255	29	76	15	38	27	32
3	162	108	490	304	49	297	23	110	15	31	26	31
4	169	110	458	166	35	238	12	75	10	35	31	31
5	177	111	183	111	31	600	11	45	9	27	27	31
6	169	99	81	85	31	482	12	87	12	21	23	31
7	154	453	1,616	104	27	1,119	12	38	10	18	23	31
8	154	685	1,736	133	21	422	151	19	10	16	23	31
9	154	190	447	270	21	157	74	18	12	14	26	27
10	154	89	203	307	23	94	81	384	11	15	28	23
11	142	65	111	173	20	67	79	1,415	7	17	30	23
12	131	58	74	169	23	56	157	398	4	217	36	23
13	295	56	37	89	23	44	265	106	10	199	63	20
14	782	51	58	68	15	33	74	1,331	1,459	106	417	17
15	1,104	49	55	59	22	23	40	593	4,395	61	440	17
16	1,144	49	112	49	35	24	28	138	868	45	487	20
17	798	49	153	44	34	23	23	72	404	39	460	23
18	454	49	344	42	27	18	19	42	99	35	226	23
19	241	36	595	39	26	13	20	31	58	29	148	83
20	158	28	740	39	22	15	26	517	41	33	148	125
21	131	23	318	35	16	15	33	749	32	2,004	154	69
22	489	2,090	343	31	14	19	31	286	31	1,035	126	31
23	3,133	632	425	27	17	47	26	184	31	261	90	31
24	1,098	272	301	23	15	37	20	119	31	124	76	51
25	282	218	127	22	10	21	18	59	25	78	67	71
26	175	128	341	30	10	15	39	43	19	60	58	71
27	155	76	322	66	9	13	31	34	21	53	45	238
28	144	39	151	112	8	13	27	26	23	41	44	556
29	132	173	104	109	7	16	77	27	18	36	49	431
30	120	.....	82	79	18	25	44	25	49	38	44	154
31	116	.....	334	.....	715	.....	30	20	.....	36	.....	113

Estimated monthly discharge of Tohickon Creek at Point Pleasant, Pa., for 1904.

[Drainage area, 102.2 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	3,133	116	412	4.03	4.65
February	2,090	23	214	2.09	2.25
March	1,736	55	354	3.46	3.99
April	1,494	22	183	1.79	2.00
May	715	7	46.9	.459	.529
June	1,119	13	152	1.49	1.66
July	285	11	49.6	.485	.559
August	1,415	18	229	2.24	2.58
September	4,395	4	258	2.52	2.81
October	2,004	14	155	1.52	1.75
November	487	23	116	1.14	1.27
December	556	17	80.5	.788	.908
The year	4,395	4	188	1.83	24.96

NESHAMINY CREEK AT FORKS, PENNSYLVANIA.

The drainage basin of Neshaminy Creek is immediately south of that of Tohickon Creek and of a portion of that of Perkiomen Creek. The stream flows in a general southeasterly and southerly course, entering Delaware River at a point about 12 miles above Philadelphia. The point of measurement is at the forks of Big and Little Neshaminy creeks. The drainage area at this point is 139 square miles, of which 128 are cultivated and improved and 11 miles untillable and wooded. The daily discharges from 1884 to 1900 are given in Water-Supply Paper No. 47, pages 90 to 98. The table of daily discharge for 1904 was furnished by Mr. John E. Codman.

Mean daily discharge, in second-feet, of Neshaminy Creek at forks, Pennsylvania, for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	119	144	768	1,549	83	153	26	55	53	47	93	54
2	92	135	463	632	72	124	24	79	50	42	85	51
3	88	125	369	288	63	113	21	65	52	38	81	51
4	88	125	321	195	51	84	18	44	47	37	78	54
5	88	125	243	161	47	334	17	34	41	35	75	54
6	88	518	80	148	43	414	22	396	38	39	69	54
7	88	2,274	3,137	179	40	2,502	118	91	34	33	68	51
8	88	864	1,637	194	38	360	1,314	46	29	27	71	48
9	92	125	277	513	38	189	149	36	28	29	72	48
10	105	125	135	564	39	147	17	1,143	31	30	75	48
11	105	125	103	235	38	135	130	1,546	31	33	169	48
12	105	115	91	188	35	107	80	256	31	2,577	125	45
13	344	89	73	164	34	80	82	243	31	361	408	41
14	1,060	72	71	137	33	72	73	1,012	132	167	1,558	41
15	955	72	75	118	40	68	43	268	3,911	120	540	41
16	532	63	194	104	42	57	39	135	323	101	492	41
17	189	54	232	93	37	48	37	102	176	92	419	41
18	154	54	755	86	36	45	32	87	135	85	238	41
19	125	54	995	85	33	42	31	72	113	77	201	41
20	105	63	383	80	33	39	30	1,596	94	72	188	41
21	105	118	205	75	33	41	29	482	84	3,560	176	41
22	1,592	4,007	385	71	29	94	27	224	76	502	152	39
23	4,696	304	473	67	31	80	23	233	68	262	138	31
24	1,336	182	253	61	28	33	20	162	59	198	125	71
25	380	134	208	63	19	30	22	120	54	174	111	52
26	470	105	329	72	20	26	235	97	55	155	105	157
27	450	89	328	103	18	21	203	86	55	136	83	246
28	314	237	181	131	15	22	48	79	51	115	59	1,090
29	213	613	143	117	15	27	48	73	46	105	54	565
30	189	.....	125	98	19	28	37	64	47	101	54	200
31	154	.....	380	.....	246	.....	30	58	.....	97	.....	153

Estimated monthly discharge of Neshaminy Creek at forks, Pennsylvania, for 1904.

[Drainage area, 139 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	4,696	88	468	3.37	3.88
February	4,007	54	383	2.76	2.98
March	3,137	71	433	3.12	3.60
April	1,549	61	219	1.58	1.76
May	246	15	43.5	.320	.369
June	2,502	21	184	1.32	1.47
July	1,314	17	97.6	.702	.809
August	1,596	34	290	2.09	2.41
September	3,911	28	199	1.43	1.60
October	3,560	27	305	2.19	2.52
November	1,558	54	205	1.47	1.64
December	1,090	31	114	.820	.945
The year	4,696	15	245	1.76	23.98

SCHUYLKILL RIVER NEAR PHILADELPHIA.

This river receives the drainage of the portion of southeastern Pennsylvania lying between Lehigh River on the north and Susquehanna River on the south. It flows in a general southeasterly course, emptying into Delaware River, the city of Philadelphia being located at the junction of these streams. Records of the height of the river at Fairmount pool have been kept for many years, but not in such form as to be useful in computing daily discharges. In 1898, however, careful estimates were prepared by Mr. John E. Codman, in charge of hydrographic work, Bureau of Water, city of Philadelphia, the results being given in the Twentieth Annual Report, Part IV, page 97.

The figures for daily discharge in the following table represent the total flow of the stream, computed from the amount wasted over the flashboards at Fairmount dam, the pumpage from the river, the leakage, and also the quantity used for power at Fairmount.

The following figures for 1904 were furnished by Mr. John E. Codman:

Mean daily discharge, in second-feet, of Schuylkill River near Philadelphia, Pa., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1,303	1,445	9,045	6,469	1,292	7,092	771	1,595	994	1,360	1,495	1,258
2	1,303	1,445	8,934	12,470	1,292	4,294	771	1,595	994	1,360	1,495	1,258
3	1,303	1,445	6,429	8,434	1,292	5,048	771	1,595	994	1,360	1,495	1,258
4	1,303	1,445	8,850	5,634	1,292	4,458	771	1,607	994	1,360	1,495	1,258
5	1,303	1,445	5,129	6,572	1,292	2,991	771	1,595	994	1,360	1,495	1,258
6	1,303	1,445	3,092	3,391	1,292	4,138	771	1,595	994	1,360	1,495	1,258
7	1,303	2,439	11,860	3,120	1,292	12,850	771	1,595	994	1,360	1,495	1,258
8	1,303	6,187	36,180	3,120	1,292	4,136	871	1,595	994	1,360	1,495	1,258
9	1,303	3,187	14,320	3,484	1,292	3,270	803	1,595	994	1,360	1,495	1,258
10	1,303	2,024	7,589	4,003	1,292	3,002	771	1,595	994	1,360	1,495	1,258
11	1,303	1,445	5,289	3,391	1,292	3,630	771	5,339	994	1,360	1,495	1,258
12	1,303	1,445	3,994	2,887	1,292	2,743	771	3,500	994	4,002	1,495	1,258
13	1,426	1,445	4,064	2,453	1,292	1,818	771	1,595	994	1,873	1,535	1,258
14	2,910	1,445	2,755	2,034	1,292	1,780	771	2,568	5,456	1,483	5,173	1,258
15	3,215	1,445	2,498	2,034	1,292	1,729	771	3,137	29,490	1,360	5,264	1,258
16	2,064	1,445	2,426	1,866	1,292	1,729	771	1,673	4,044	1,360	3,678	1,258
17	1,303	1,445	2,483	1,774	1,292	1,729	771	1,595	994	1,360	2,930	1,258
18	1,303	1,445	3,675	1,774	1,292	1,729	771	1,595	994	1,360	1,857	1,258
19	1,303	1,445	6,135	1,774	1,292	1,729	771	1,595	994	1,360	2,454	1,258
20	1,303	1,445	5,925	1,774	1,292	1,729	771	3,354	994	1,360	2,375	1,258
21	1,303	1,445	4,756	1,774	1,292	1,729	771	3,981	994	11,350	2,375	1,258
22	3,988	22,810	4,475	1,774	1,292	1,729	771	3,034	994	10,780	2,211	1,258
23	27,210	21,420	4,650	1,774	1,292	1,729	771	3,679	994	4,927	1,822	1,258
24	14,050	6,537	3,963	1,774	1,292	1,729	771	3,506	994	2,909	1,671	1,258
25	7,003	5,058	3,397	1,774	1,292	1,729	771	1,758	994	1,961	1,642	1,258
26	3,753	4,591	3,585	1,774	1,292	1,501	771	1,595	994	1,419	1,495	1,258
27	5,369	2,558	3,945	1,774	1,292	1,325	771	1,595	994	1,360	1,495	1,258
28	1,946	2,654	3,585	1,774	1,432	1,325	803	1,595	994	1,360	1,495	3,531
29	1,433	4,474	3,061	2,034	1,292	1,325	771	1,595	994	1,360	1,495	4,200
30	1,303	.....	2,691	1,866	1,292	1,325	771	1,595	994	1,360	1,495	3,063
31	1,303	.....	3,112	.....	5,997	.....	771	1,595	.....	1,360	.....	3,045

NOTE.—The above is the total flow of the river in second-feet.

Estimated monthly discharge of Schuylkill River near Philadelphia, Pa., for 1904.

[Drainage area, 1,915 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	27,210	1,303	3,196	1.67	1.92
February	22,810	1,445	3,742	1.95	2.10
March	36,180	2,426	6,187	3.23	3.72
April	12,470	1,774	3,218	1.68	1.87
May	5,997	1,292	1,448	.756	.872
June	12,850	1,325	2,901	1.51	1.68
July	871	771	776	.405	.467
August	5,339	1,595	2,176	1.14	1.31
September	29,490	994	2,194	1.15	1.28
October	11,350	1,360	2,278	1.19	1.37
November	5,264	1,495	2,013	1.05	1.17
December	4,200	1,258	1,542	.805	.928
The year	36,180	771	2,639	1.38	18.69

NOTE.—The above is the total flow of the river.

PERKIOMEN CREEK AT FREDERICK, PA.

Perkiomen Creek drains an area lying northwest of the city of Philadelphia. It flows in a southerly direction, emptying into Schuylkill River about 7 miles above Norristown and about 18 miles above Philadelphia. The point of measurement of discharge is located at Frederick about 12 miles above the mouth, and is also above two large tributaries known as West Swamp Creek and Northeast Branch of Perkiomen. Both of these tributaries have been measured—the first at Zieglerville and the second near Schwenkville. The drainage area of the Perkiomen above the point of measurement is given by Rudolph Hering as 152 square miles, of which 111 are cultivated and improved and 41 untillable and wooded. Measurements of this creek were begun on August 20, 1884. Water-Supply Paper No. 35 contains tables of the daily discharge for the entire period from 1884 to 1899, inclusive. The records of daily discharge for 1904, as furnished by Mr. John E. Codman, are given in the following table:

Mean daily discharge, in second-feet, of Perkiomen Creek at Frederick, Pa., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	54	121	670	1,763	133	305	208	44	53	82	80	97
2	97	154	613	921	107	398	91	58	46	58	74	92
3	87	119	694	365	93	594	67	106	46	60	68	86
4	133	124	818	252	74	288	45	96	46	65	62	69
5	131	106	211	214	64	503	38	60	46	57	55	78
6	124	88	174	201	62	381	39	269	60	61	51	95
7	126	283	3,581	212	55	2,583	164	126	55	63	59	88
8	128	1,351	2,629	228	58	406	333	63	36	52	67	88
9	126	243	391	279	55	231	157	46	34	46	64	86
10	121	167	216	294	69	183	157	490	33	46	59	78
11	114	114	178	231	70	158	167	1,376	34	54	75	75
12	106	108	152	198	60	131	104	258	47	159	84	75
13	106	103	132	167	52	100	76	130	52	258	147	75
14	765	61	128	138	53	88	72	1,885	1,594	106	634	66
15	587	71	128	118	75	84	63	367	5,460	76	462	72
16	340	118	171	99	123	61	49	172	457	63	451	100
17	233	67	211	98	94	60	45	121	224	59	460	98
18	226	57	299	97	67	64	44	94	148	62	306	82
19	226	56	1,095	92	54	52	50	70	126	61	233	95
20	148	69	892	79	65	55	75	570	100	58	261	102
21	139	79	349	65	69	153	84	768	76	3,821	290	92
22	1,087	3,815	337	61	64	384	61	250	71	820	238	92
23	4,465	563	447	59	65	112	45	334	67	298	194	92
24	671	497	320	60	58	66	42	167	64	202	176	150
25	247	359	256	61	45	45	42	120	58	163	156	214
26	205	189	353	68	35	43	53	92	69	142	128	199
27	224	106	360	130	37	41	128	64	75	124	102	312
28	164	129	228	186	37	40	99	60	70	103	108	1,006
29	116	376	180	183	36	66	66	60	70	87	113	659
30	118	.....	180	163	52	88	62	58	83	80	101	320
31	124	.....	289	.....	1,117	.....	54	58	.....	84	.....	214

Estimated monthly discharge of Perkiomen Creek at Frederick, Pa., for 1904.

[Drainage area, 152 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	4,465	54	371	2.44	2.81
February	3,815	55	334	2.20	2.37
March	3,581	128	538	3.54	4.08
April	1,763	59	236	1.55	1.73
May	1,117	35	99.8	.657	.757
June	2,583	40	259	1.70	1.90
July	333	38	89.5	.589	.679
August	1,885	44	272	1.79	2.06
September	5,460	33	313	2.06	2.30
October	3,821	46	241	1.59	1.83
November	634	51	179	1.18	1.32
December	1,006	66	163	1.07	1.23
The year	5,460	33	258	1.70	23.07

INDEX.

Batavia Kill near—
Prattsville, N. Y.: Page.
description 59
Bloomsbury, N. J.
Musconetcong River near:
description 102-103
discharge 103
gage heights 103
Boonton, N. J.
Rockaway River near:
description 84
discharge 84
gage heights 84
Boundbrook, N. J.
Raritan River at:
description 90
discharge 90
gage heights 91
Buskirk, N. Y.
Hoosic River at:
description 24-25
discharge 25
gage heights 26
Catskill Creek at—
South Cairo, N. Y.:
description 60
discharge 60
discharge, mean daily 62
discharge, monthly 63
gage heights 61
rating table 62
Champlain Canal feeder at—
Glens Falls, N. Y.:
discharge 73
Chatham, N. J.
Passaic River near:
description 76
discharge 76
gage heights 77
Croton River at—
Old Croton dam, New York:
description 71-72
discharge, monthly 72
Deerfield, N. Y.
Deerfield reservoir near:
rainfall 44
Johnston Brook near
description 41-42
discharge, mean daily 43
discharge, monthly 44
Reels Creek near:
description 41-42
discharge mean daily 42
discharge, monthly 43
Deerfield reservoir near—
Deerfield, N. Y.: Page.
rainfall 44
Delaware River at—
Lambertville, N. J.:
description 99-100
discharge 100
gage heights 100
Delaware River (East Branch) at—
Hancock, N. Y.:
description 98
discharge 98
gage heights 99
Delaware River (West Branch) at—
Hancock, N. Y.:
description 96
discharge 96
gage heights 97
Delaware River drainage basin:
description 94-95
Dolgeville, N. Y.
East Canada Creek at:
description 50-51
discharge, mean daily 51-52
discharge, monthly 53
Dunsbach Ferry Bridge, New York.
Mohawk River at:
description 29-30
discharge, mean daily 30-31
discharge, monthly 32
East Canada Creek at—
Dolgeville, N. Y.:
description 50-51
discharge, mean daily 51-52
discharge, monthly 53
Esopus Creek at and near—
Kingston, N. Y.:
description 66-67
discharge 67
discharge, mean daily 69
discharge, monthly 69
gage heights 67
rating table 68
Olivebridge, N. Y.:
description 63
discharge 63
discharge, mean daily 65-66
discharge, monthly 66
gage heights 64
rating table 64
Finderne, N. J.
Raritan River at:
description 87-88
discharge 88

Finderne, N. J.—Continued.
Raritan River at—Continued. Page.
discharge, monthly 89
gage heights 88
rating table 89
Fort Edward, N. Y.
Hudson River at:
description 19–20
discharge, mean daily 20–21
discharge, monthly 22
Frederick, Pa.
Perkiomen Creek at:
description 108
discharge, mean daily 109
discharge, monthly 110
Glens Falls, N. Y.
Champlain Canal feeder at:
discharge 73
Graefenberg Creek near—
New Hartford, N. Y.:
description 39
rainfall 40
Graefenberg reservoir near—
New Hartford, N. Y.:
rainfall 40
Hancock, N. Y.
Delaware River (East Branch) at:
description 98
discharge 98
gage heights 99
Delaware River (West Branch) at:
description 96
discharge 96
gage height 97
Hoosic River at—
Buskirk, N. Y.:
description 24–25
discharge 25
gage heights 26
Hudson River at—
Fort Edward, N. Y.:
description 19–20
discharge, mean daily 20–21
discharge, monthly 22
Mechanicsville, N. Y.:
description 22–23
discharge, mean daily 23
discharge, monthly 23
Indian Lake, New York.
Indian River at:
description 24
stage of water 24
Indian River at—
Indian Lake, New York:
description 24
stage of water 24
Johnston Brook near—
Deerfield, N. Y.:
description 41–42
discharge, mean daily 43
discharge, monthly 44
Kingston, N. Y.
Esopus Creek at
description 66–67
discharge 67
discharge, mean daily 69
discharge, monthly 69
Kingston, N. Y.—Continued.
Esopus Creek at—Continued. Page.
gage heights 67
rating table 68
Lambertville, N. J.
Delaware River at:
description 99–100
discharge 100
gage heights 100
Lehigh River near—
South Bethlehem, Pa.:
description 101
discharge 101
gage heights 102
Little Falls, N. Y.
Mohawk River at:
description 26–27
discharge, mean daily 27–28
discharge, monthly 28–29
Mahwah, N. J.
Ramapo River near:
description 79–80
discharge 80
discharge, monthly 81–82
gage heights 80
rating table 81
Mechanicsville, N. Y.
Hudson River at:
description 22–23
discharge, mean daily 23
discharge, monthly 23
Millington, N. J.
Passaic River at:
description 74
discharge 74
gage heights 75
Millstone, N. J.
Millstone River at:
description 93
discharge 93
gage heights 94
Millstone River at—
Millstone, N. J.:
description 93
discharge 93
gage heights 94
Mohawk River at—
Dunsbach Ferry Bridge, New York:
description 29–30
discharge, mean daily 30–31
discharge, monthly 32
Little Falls, N. Y.:
description 26–27
discharge, mean daily 27–28
discharge, monthly 28–29
Musconetcong River near—
Bloomsbury, N. J.
description 102–103
discharge 103
gage heights 103
Nail Creek at—
Utica, N. Y.:
description 45–46
discharge, mean daily 46
discharge, monthly 46

Neshaminy Creek at—
Forks, Pennsylvania: Page.
description 105
discharge, mean daily..... 106
discharge, monthly 106
New Hartford, N. Y.
Graefenberg Creek near:
description 39
Graefenberg reservoir near:
rainfall..... 40
Starch Factory Creek near:
description..... 35
discharge, mean daily..... 36
discharge, monthly 37
Sylvan Glen Creek near:
description 37
discharge, mean daily..... 38
discharge, monthly 39
Nine Mile Creek near—
Oriskany, N. Y.:
discharge..... 73
Old Croton dam, New York
Croton River at:
description..... 71–72
discharge, monthly 72
Olivebridge, N. Y.
Esopus Creek near:
description 63
discharge..... 68
discharge, mean daily..... 65–66
discharge, monthly 66
gage heights 64
rating table..... 64
Oriskany, N. Y.
Nine Mile Creek near:
discharge..... 73
Oriskany Creek near:
description 32–33
discharge..... 33
discharge, mean daily..... 34
discharge, monthly 35
gage heights..... 33–34
Oriskany Creek near—
Oriskany, N. Y.:
description 32–33
discharge..... 33
discharge, mean daily..... 34
discharge, monthly 35
gage heights..... 33–34
Passaic River at and near—
Chatham, N. J.:
description..... 76
discharge..... 76
gage heights..... 77
Millington, N. J.:
description 74
discharge..... 74
gage heights..... 75
Passaic River drainage basin
description 73–74
Perkiomen Creek at—
Frederick, Pa.:
description 108
discharge, mean daily..... 109
discharge, monthly..... 110
Philadelphia, Pa.
Schuylkill River near:
description 107
Philadelphia, Pa.—Continued.
Schuylkill River near—Continued. Page.
discharge, mean daily..... 107
discharge, monthly 108
Pluckemin, N. J.
Raritan River (North Branch) near:
description 91–92
discharge..... 92
gage heights..... 92
Point Pleasant, Pa.
Tohickon Creek at:
description 104
discharge, mean daily..... 104
discharge, monthly..... 105
Pompton Plains, N. J.
Pompton River at:
description 78
gage heights..... 79
Pompton River at—
Pompton Plains, N. J.:
description 78
gage heights..... 79
Prattsville, N. Y.
Batavia Kill near:
description 59
Schoharie Creek at:
description 54
discharge..... 54
discharge, mean daily..... 57–58
discharge, monthly..... 59
gage heights..... 55
rating table..... 56
Ramapo River near—
Mahwah, N. J.:
description 79–80
discharge..... 80
discharge, monthly..... 81–82
gage heights..... 80
rating table..... 81
Raritan River at—
Bound Brook, N. J.:
description 90
discharge..... 90
gage heights..... 91
Finderne, N. J.:
description 87–88
discharge..... 88
discharge, monthly..... 89
gage heights..... 88
rating table..... 89
Raritan River (North Branch) near—
Pluckemin, N. J.:
description 91–92
discharge..... 92
gage heights..... 92
Raritan River (South Branch) at—
Stanton, N. J.:
description 85–86
discharge..... 86
discharge, monthly 87
gage heights..... 86
rating table 87
Raritan River drainage basin:
description 84–85
Reels Creek near—
Deerfield, N. Y.:
description 41–42

Reels Creek near—Continued.
Deerfield, N. Y.—Continued. Page.
discharge, mean daily..... 42
discharge, monthly 43
Rockaway River near—
Boonton, N. J.:
description 84
discharge..... 84
gage heights..... 84
Savage reservoir near—
Utica, N. Y.:
rainfall..... 41
Schoharie Creek at—
Prattsville, N. Y.:
description 54
discharge..... 54
discharge, mean daily..... 57–58
discharge, monthly..... 59
gage heights 55
rating table 56
Schuylkill River near—
Philadelphia, Pa.:
description 107
discharge, mean daily 107
discharge, monthly 108
South Bethlehem, Pa.—
Lehigh River near:
description 101
discharge..... 101
gage heights 102
South Cairo, N. Y.
Catskill Creek at:
description 60
discharge..... 60
discharge, mean daily..... 62
discharge, monthly 63
gage heights..... 61
rating table 62
Stanton, N. J.
Raritan River (South Branch) at:
description 85–86
discharge..... 86
discharge, monthly 87
gage heights 86
rating table 87
Starch Factory Creek near—
New Hartford, N. Y.:
description 35
discharge, mean daily..... 36
discharge, monthly..... 37
Sylvan Glen Creek near—
New Hartford, N. Y.: Page
description 3
discharge, mean daily..... 3
discharge, monthly 3
Tohickon Creek at—
Point Pleasant, Pa.:
description 3
discharge, mean daily..... 3
discharge, monthly 3
Twin Rock Bridge, N. Y.
West Canada Creek at:
description 46–4
discharge..... 4
discharge, mean daily 4
discharge, monthly..... 4
gage heights 4
Utica, N. Y.
Nail Creek at:
description 45–4
discharge, mean daily..... 4
discharge, monthly 4
Savage Reservoir near:
rainfall..... 4
Wanaque, N. J.
Wanaque River at:
description 82–8
discharge..... 8
gage heights..... 8
Wanaque River at—
Wanaque, N. J.:
description 82–8
discharge..... 8
gage heights..... 8
Wappinger Creek near—
Wappinger Falls, N. Y.:
description 7
discharge..... 7
gage heights..... 7
Wappinger Falls, N. Y.
Wappinger Creek near:
description 7
discharge..... 7
gage heights..... 7
West Canada Creek at—
Twin Rock Bridge, N. Y.:
description 46–4
discharge..... 4
discharge, mean daily..... 4
discharge, monthly 4
gage heights..... 4

O

PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Water-Supply Paper No. 125.]

The publications of the United States Geological Survey consist of (1) Annual Reports; (2) Monographs; (3) Professional Papers; (4) Bulletins; (5) Mineral Resources; (6) Water-Supply and Irrigation Papers; (7) Topographic Atlas of United States, folios and separate sheets thereof; (8) Geologic Atlas of United States, folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

Most of the above publications may be obtained or consulted in the following ways:

1. A limited number are delivered to the Director of the Survey, from whom they may be obtained, free of charge (except classes 2, 7, and 8), on application.

2. Every member of Congress is allotted a certain number, from whom they may be obtained, free of charge, on application.

3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they may be had at practically cost.

4. Copies of all Government publications are furnished to the principal public libraries in the large cities throughout the United States, where they may be consulted by those interested.

The Professional Papers, Bulletins, and Water-Supply Papers treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous; H, Forestry; I, Irrigation; J, Water storage; K, Pumping water; L, Quality of water; M, General hydrographic investigations; N, Water power; O, Underground waters; P, Hydrographic progress reports.

Series P.—The hydrographic progress reports contain the results of stream measurements. A report is issued for every calendar year, containing the results of data collected during that year. These reports were first published as a part of the Director's annual report or as a bulletin; they are now published as water-supply and irrigation papers. The following is a list, by years, of the publications containing the progress reports of stream measurements. A detailed index of these reports (1888–1903) is published as Water-Supply Paper No. 119.

1888. Tenth Annual Report, Part II.
1889. Eleventh Annual Report, Part II.
1890. Twelfth Annual Report, Part II.
1891. Thirteenth Annual Report, Part III.
1892. Fourteenth Annual Report, Part II.
1893. Bulletin No. 131.
1894. Bulletin No. 131; Sixteenth Annual Report, Part II.
1895. Bulletin No. 140.
1896. Water-Supply Paper No. 11; Eighteenth Annual Report, Part IV.
1897. Water-Supply Papers Nos. 15 and 16; Nineteenth Annual Report, Part IV.
1898. Water-Supply Papers Nos. 27 and 28, Twentieth Annual Report, Part IV.
1899. Water-Supply Papers Nos. 35, 36, 37, 38, and 39, Twenty-first Annual Report, Part IV.
1900. Water-Supply Papers Nos. 47, 48, 49, 50, 51, and 52, Twenty-second Annual Report, Part IV.
1901. East of Mississippi River, Water-Supply Papers Nos. 65 and 75.
West of Mississippi River, Water-Supply Papers Nos. 66 and 75.
1902. East of Mississippi River, Water-Supply Papers Nos. 82 and 83.
West of Mississippi River, Water-Supply Papers Nos. 84 and 85.

1903. East of Mississippi River, Water-Supply Papers Nos. 97 and 98.
West of Mississippi River, Water-Supply Papers Nos. 99 and 100.
1904. East of Mississippi River, Water-Supply Papers Nos. 124, 125, 126, 127, 128, and 129.
West of Mississippi River, Water-Supply Papers Nos. 130, 131, 132, 133, 134, and 135.

The Geological Survey and the Reclamation Service have suboffices in different parts of the United States, from which hydrographic and reclamation work in the respective localities is carried on and where data may be obtained on application. These offices are located as follows:

Boston, Mass., 6 Beacon street; Utica, N. Y., 75 Arcade; Atlanta, Ga., 409 Temple court; Austin, Tex., University of Texas; Chicago, Ill., Federal Building; Belle Fourche, S. Dak.; Cody, Wyo.; Denver, Colo., Chamber of Commerce Building; Salt Lake, Utah; Los Angeles, Cal., 1108 Braly Building; San Francisco, Cal., 422 Merchants' Exchange Building; Phoenix, Ariz.; Carlsbad, N. Mex.; El Paso, Tex.; Billings, Mont.; Great Falls, Mont.; Hazen, Nev.; Boise, Idaho; Spokane, Wash., 424 Peyton Block; Pendleton, Oreg.

Correspondence should be addressed to

THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, D. C.

JULY, 1905.

LIBRARY CATALOGUE SLIPS.

[Mount each slip upon a separate card, placing the subject at the top of the second slip. The name of the series should not be repeated on the series card, but the additional numbers should be added, as received, to the first entry.]

Author.

U. S. Geological survey.

. . . Report of progress of stream measurements for the calendar year 1904. Prepared under the direction of F. H. Newell by R. E. Horton, N. C. Grover, and John C. Hoyt. pt. II. Hudson, Passaic, Raritan, and Delaware River drainages. Washington, Gov't print. off., 1905.

114, iii p. illus., II pl. (incl. map) 23cm. (*Its* Water-supply and irrigation paper no. 125)

Subject series: P, Hydrographic progress reports, 30.

1. Stream measurements. 2. Rivers—U. S. I. Horton, Robert Elmer, 1875– II. Grover, Nathan Clifford, 1868– III. Hoyt, John Clayton, 1874–

Subject.

U. S. Geological survey.

. . . Report of progress of stream measurements for the calendar year 1904. Prepared under the direction of F. H. Newell by R. E. Horton, N. C. Grover, and John C. Hoyt. pt. II.—Hudson, Passaic, Raritan, and Delaware River drainages. Washington, Gov't print. off., 1905.

114, iii p. illus., II pl. (incl. map) 23cm. (*Its* Water-supply and irrigation paper no. 125)

Subject series: P, Hydrographic progress reports, 30.

1. Stream measurements. 2. Rivers—U. S. I. Horton, Robert Elmer, 1875– II. Grover, Nathan Clifford, 1868– III. Hoyt, John Clayton, 1874–

Series.

U. S. Geological survey.

Water-supply and irrigation papers.

no. 125. Report of progress of stream measurements for . . . 1904 . . . by R. E. Horton, N. C. Grover, and J. C. Hoyt. pt. II. 1905.

Reference.

U. S. Dept. of the Interior.

see also

U. S.. Geological survey.

Water-Supply and Irrigation Paper No. 126 Series P, Hydrographic Progress Reports, 31

DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

REPORT

OF

PROGRESS OF STREAM MEASUREMENTS

FOR

THE CALENDAR YEAR 1904

PREPARED UNDER THE DIRECTION OF F. H. NEWELL

BY

N. C. GROVER and JOHN C. HOYT

PART III.—Susquehanna, Patapsco, Potomac, James, Roanoke, Cape Fear, and Yadkin River Drainages

WASHINGTON

GOVERNMENT PRINTING OFFICE

1905

CONTENTS.

	Page.
Letter of transmittal	5
Introduction	7
Cooperation and acknowledgments	16
Susquehanna River drainage basin	17
Susquehanna River at Binghamton, N. Y	18
Susquehanna River at Wilkesbarre, Pa	22
Susquehanna River at Danville, Pa	27
Susquehanna River at Harrisburg, Pa	29
Susquehanna River at McCall Ferry, Pa	34
Chenango River at Binghamton, N. Y	39
Chemung River at Chemung, N. Y	43
Susquehanna River (West Branch) at Williamsport, Pa	48
Juniata River at Newport, Pa	52
Broad Creek at Mill Green, Md	55
Deer Creek near Churchville, Md	56
Gunpowder River drainage basin	56
Gunpowder Falls at Glencoe, Md	57
Little Gunpowder Falls near Belair, Md	57
Patapsco River drainage basin	58
Patapsco River at Woodstock, Md	58
Potomac River drainage basin	60
Potomac River (North Branch) at Piedmont, W. Va	61
Potomac River at Point of Rocks, Md	63
Potomac River (South Branch) near Springfield, W. Va	66
Antietam Creek near Sharpsburg, Md	67
Shenandoah River at Millville, W. Va	69
Shenandoah River (South Branch) near Front Royal, Va	72
Shenandoah River (North Branch) near Riverton, Va	75
Monocacy River near Frederick, Md	76
James River drainage basin	79
James River at Buchanan, Va	81
James River at Holcomb Rock, Va	84
James River at Cartersville, Va	85
North (of James) River near Glasgow, Va	88
Appomattox River at Mattoax, Va	91
Roanoke River drainage basin	94
Roanoke River at Roanoke, Va	95
Staunton River at Randolph, Va	98
Dan River at Madison, N. C	100
Dan River at South Boston, Va	103
Mayo River at Madison, N. C	106
Banister River at Houston, Va	106

	Page.
Pedee, or Yadkin, River drainage basin	107
Yadkin River near Salisbury, N. C	109
Yadkin River at North Wilkesboro, N. C	112
Reddie River at North Wilkesboro, N. C	115
Mulberry River near North Wilkesboro, N. C	115
Roaring River at Roaring River, N. C	116
Mitchell River at Burch, N. C	117
Fisher River near Crutchfield, N. C	117
Ararat River near Siloam, N. C	118
Miscellaneous measurements in Yadkin River drainage basin	119
Index	121

ILLUSTRATIONS.

	Page.
PLATE I. Map showing location of principal gaging stations in the United States	8
II. Price electric-current meters with buzzers	10
FIG. 1. Cable station, showing section of the river, car, gage, etc	9

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
HYDROGRAPHIC BRANCH,
Washington, D. C., February 4, 1905.

SIR: I transmit herewith the manuscript of Part III of a series of twelve papers which compose the Report of Progress of Stream Measurements for the Calendar Year 1904. Parts I to VI of this report contain the results of the data collected in the territory east of the Mississippi River. Parts VII to XII are devoted to the data collected in the territory west of the Mississippi River.

The larger part of the original data for this report was collected under the direction of district hydrographer N. C. Grover, who was assisted by H. D. Comstock. The assembling of the data and their preparation for publication were done under the direction of John C. Hoyt, who has been assisted by R. H. Bolster, Robert Follansbee, Willis E. Hall, and A. H. Horton.

I request that this manuscript be published as one of the series of Water-Supply and Irrigation Papers.

Very respectfully,

F. H. NEWELL, *Chief Engineer.*

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

PROGRESS REPORT OF STREAM MEASUREMENTS FOR THE CALENDAR YEAR 1904.

PART III.

By N. C. Grover and John C. Hoyt.

INTRODUCTION.

The hydrographic work of the United States Geological Survey includes the collection of facts concerning and the study of conditions affecting the behavior of water from the time it reaches the earth as rain or snow until it joins the oceans or great navigable rivers. These investigations became a distinct feature of the work of the Survey in the fall of 1888, when an instruction camp was established at Embudo, N. Mex. Since that date the work has been continually and gradually extended as larger funds became available. The first distinctive appropriation for gaging streams was made by the act of August 18, 1894, which contained an item of $12,500, "for gaging the streams and determining the water supply of the United States, including the investigation of underground currents and artesian wells in the arid and semiarid sections." (Digest of Appropriations for 1895, p. 270.)

Since that time a similar act has been passed each year and the appropriations have gradually increased, as shown in the following table:

Annual appropriations for hydrographic surveys.

Year ending June 30, 1895	$12,500
Year ending June 30, 1896	20,000
Year ending June 30, 1897	50,000
Year ending June 30, 1898	50,000
Year ending June 30, 1899	50,000
Year ending June 30, 1900	50,000
Year ending June 30, 1901	100,000
Year ending June 30, 1902	100,000
Year ending June 30, 1903	200,000
Year ending June 30, 1904	200,000
Year ending June 30, 1905	200,000

The chief feature of the work of the hydrographic division is the systematic study of the flow of the surface waters and the conditions affecting the same. In this connection other information that may be of use to the engineer or others in hydrographic studies, such as river profiles, duration and extent of damage by floods, water-power data, etc., is collected. Furthermore, the work has been so directed that the information collected will be of direct value in the commercial and agricultural development of the country.

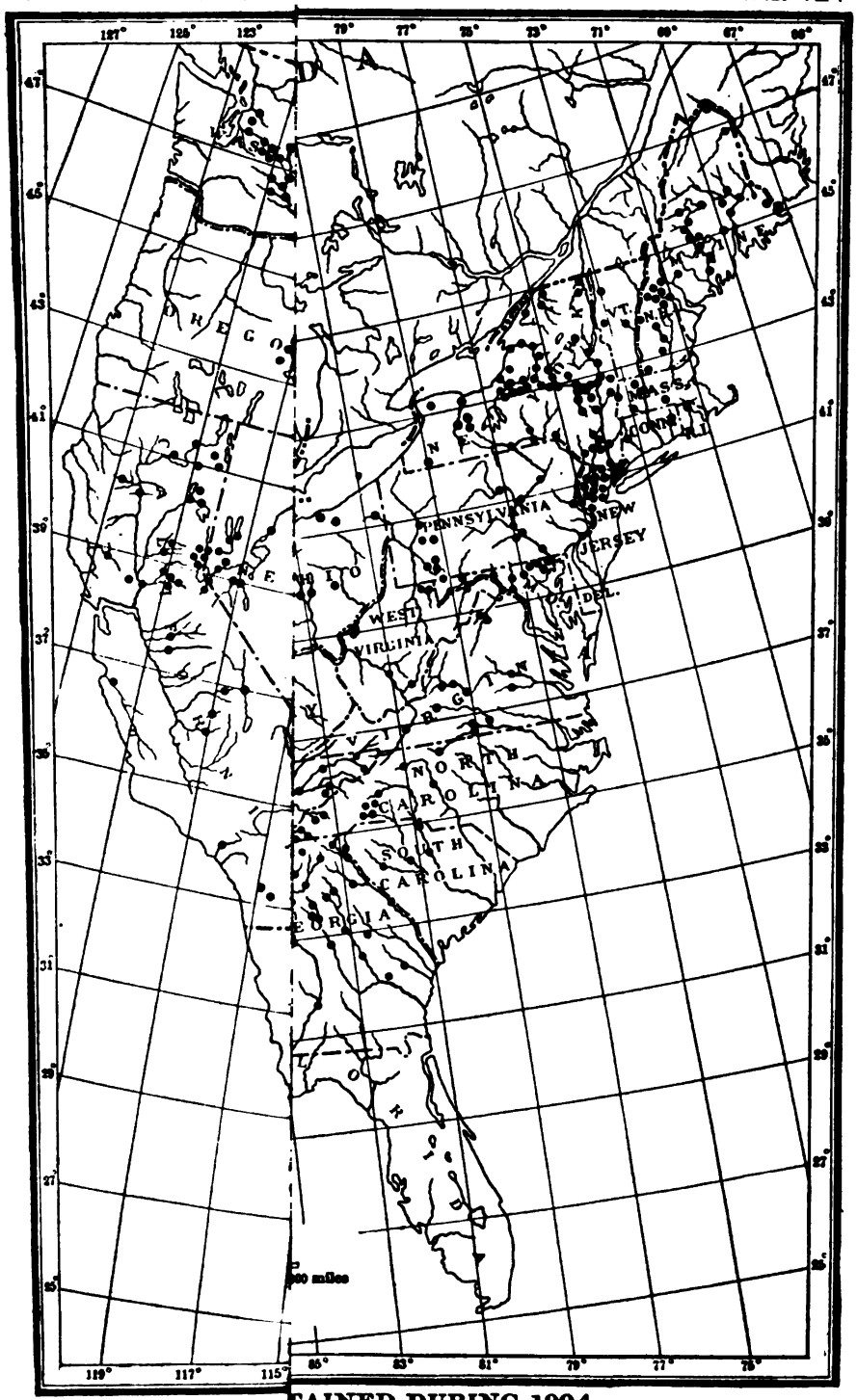
As a result of the increased appropriations since June 30, 1902, the work has been largely extended and thoroughly systemized. The various States have been grouped into districts, each of which is under the supervision of a district hydrographer who, with a corps of assistants, devotes his whole time to the study of the hydrographic resources of his district.

The methods used in the collection of these data and in their preparation for publication are given in detail in Water-Supply Paper No. 94. (Hydrographic Manual, U. S. Geol. Survey.)

The general plan of stream gaging which has been developed is to obtain eventually data in regard to the flow of all the important streams in the United States. With this in view gaging stations are established at points where the data will be of greatest commercial value. At these stations discharge measurements are taken from time to time at typical river stages, and the daily surface fluctuation is obtained by means of gage readings. From these two factors it is possible to estimate both the total flow and its distribution through the period of observations.

The selection of the site for a gaging station and the length of time the station is maintained depend largely upon the needs of each locality. If the stream is to be used for water power, special efforts are made to obtain information concerning the low-water flow. If water is to be stored, the high waters are given special attention. In all sections certain permanent stations are maintained for general statistical purposes to show the conditions which exist through long periods. They also act as primary stations, and are used in connection with short series of measurements to determine the flow in particular portions of the drainage basin.

Gaging stations are divided into two general classes: First, current-meter stations; and second, weir stations. The former class is subdivided as to location into bridge, cable, boat, and wading stations. Fig. 1 shows a cable station with car, tag-line, inclined gage, etc. In addition to the bridge, cable, or boat, the equipment of a current-meter gaging station consists in a gage for determining the daily fluctuations of the water surface, bench marks to which the zero of the gage is referred, and permanent marks on the bridge or a tagged line indicating the points of measurement. Where the current is swift some appli-



MAINED DURING 1904.

ance—generally a secondary cable—is necessary to hold the meter in position below the surface.

Gaging stations are generally located at bridges, if the channel conditions are satisfactory, as from them the meter can be easily manipulated, and the cost of the equipment is comparatively small. The stations are located as far as possible at points where the channel is straight, both above and below the gaging section, and where there are no cross currents, backwater, or boils. The bed of the stream should be as clear as possible from large projections and of a permanent character. The banks should be high, and should overflow at high stages only. Great care is taken in the selection and equipment of gaging stations, in order that the data may have the required degree of accuracy.

On many of the larger rivers where water power is developed by dams estimates of flow are obtained by observing the head on the crest and using a weir formula. On the smaller streams sharp-crested weirs are in some cases erected.

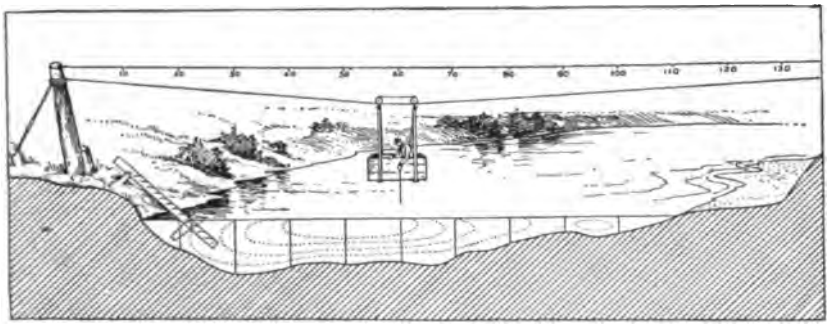


FIG. 1.—Cable station, showing section of river, car, gage, etc.

The principal instrument used in stream-measurement work is the current meter, by which the velocity of the flow of water is determined. After years of experience the Survey has adopted the Price current meter for géneral work. This meter, as is shown on Pl. II, is made in two sizes, known as the large and small Price. The small Price has been largely developed by the officers of the Survey, using the Price acoustic meter as a basis.

A discharge measurement is the determination of the quantity of water flowing past a certain point at a given time. This quantity is the product of two factors: (1) The mean velocity, which is the function of the cross section, surface slope, wetted perimeter and roughness of bed; (2) the area, which depends upon the permanency of the bed and the fluctuations of the surface, which govern the depth.

In making the measurement an arbitrary number of points are laid off perpendicular to the thread of the stream (see fig. 1). These points

are usually at regular intervals varying from 2 to 20 feet, depending upon the size and conditions of the stream. They are known as measuring points, and at them the observed data, the velocities and soundings, are taken. The perpendiculars dropped from the measuring points divide the gaging section into strips, and for each strip or pair of strips the mean velocity, area, and discharge are determined independently; thus conditions existing in one part of the stream are not distributed to parts where they do not apply.

The methods of obtaining velocity with the current meters which are in general use may be grouped into three classes: Single point, multiple point, and integration.

The single-point method consists in holding the meter either at the depth of the thread of mean velocity, or at an arbitrary depth, for which the coefficient for reducing to mean velocity has been determined. Extensive experiments by vertical velocity-curves show that the thread of mean velocity lies at from 0.5 to 0.7 of the total depth. In general practice the thread of mean velocity is considered to be at 0.6 depth, and it is at this depth that the meter is held in the majority of the measurements, this being known as the six-tenth depth method. It is found by a large number of vertical velocity-curve measurements, taken on various streams and under various conditions, that the coefficient for reducing the velocity obtained at six-tenths depth to mean velocity is practically unity, ranging, in a series of 910 measurements made at 39 gaging stations, between 94 and 104 per cent, with a mean for the 910 observations of 100 per cent. In the other principal single-point method the meter is held near the surface, usually 1 foot below, or low enough to be out of the action of the wind or other disturbing influences. This is known as the subsurface method. The coefficient for reducing the velocities taken at the subsurface has been found by repeated experiments with vertical velocity-curves to be from 85 to 95 per cent, depending upon the depth of the stream and velocity and channel conditions. This method is specially adapted for flood measurements, or when the velocity is so great that the meter can not be kept at 0.6 depth.

The three principal multiple-point methods in general use are: The vertical velocity-curve; top and bottom; and top, bottom, and mid depth. In the vertical velocity-curve method a series of velocity determinations are taken in the vertical at regular intervals, usually from 0.5 to 1 foot apart. By plotting these velocities as abscissas and their depths as ordinates, and drawing a smooth curve through these points, the vertical velocity-curve is produced, which shows the change in velocity from the surface to the bottom of the stream. The mean velocity in the vertical is then obtained by dividing the depth into the area bounded by this mean velocity-curve and the initial line. Owing to the length of time it takes to make these measurements, they

PRICE ELECTRIC CURRENT METERS, WITH BUZZERS.

are seldom used except for determining coefficients for purposes of comparison, and for measurements under ice.

In the second multiple-point method the meter is held from 0.5 to 1 foot below the surface and about 0.5 foot above the bottom, and the mean of the velocities at these two points is taken as the mean velocity for that vertical. This method is not well adapted for general work, as the roughness of the bottom disturbs the velocity at that point. For shallow streams with comparatively smooth beds good results are obtained by this method. In the third multiple-point method the meter is held at mid depth, at 0.5 foot below the surface and at 0.5 foot above the bottom, and the mean velocity is determined by dividing the sum of the top velocity, twice the mid-depth velocity, and the bottom velocity, by 4.

The vertical-integration method consists in moving the meter at a slow, uniform speed from the surface to the bottom and back again to the surface. The number of revolutions and the time taken in the operation is noted, and the mean velocity is found by dividing the number of revolutions by the number of seconds taken in the run. This method has the advantage in that the velocity at each point of the vertical is measured twice. It is well adapted for measurements under ice and as a check on the point methods.

The area, which is the other factor for determining the discharge of the stream, depends upon the stage of the river, which is taken on a gage, and the general contour of the bed of the stream, which is found by sounding. The soundings are usually taken at each measuring point at the time of the discharge measurement, either by using the meter and cable or by a special sounding line or rod. For stations with permanent beds standard cross sections are usually taken during low water. These sections serve to check the soundings which are taken at the time of the measurements, and from them any change which may have taken place in the bed of the stream can be detected. They are also used for obtaining the area for use in computations of high-water measurements, as accurate soundings are hard to obtain at high stages.

In computing the discharge measurements from the observed velocities and depths at the various points of measurements the measuring section is divided into elementary strips, as shown in fig. 1, and the mean velocity, area, and discharge are determined separately for either a single or double strip. The total discharge and area are the sums of those for the various strips, and the mean velocity is obtained by dividing the total discharge by the total area.

The volume of water flowing in a stream is known as run-off. In expressing it various units are used, depending upon the kind of work for which the data are needed. Those used in this report are "second-feet," "acre-feet," "run-off per square mile," and "run-off in depth in inches," and may be defined as follows:

Second-foot is an abbreviation for cubic foot per second, and is the body of water flowing in a stream 1 foot wide, 1 foot deep, at a rate of 1 foot per second.

The acre-foot is the unit of capacity used in connection with storage for irrigation work, and is equivalent to 43,560 cubic feet. It is the quantity required to cover an acre to a depth of 1 foot. There is a convenient relation between the second-foot and the acre-foot: 1 second-foot flowing for twenty-four hours will deliver 86,400 cubic feet, which equals 1.9835 acre-feet, or, approximately, 2 acre-feet.

The expression "second-feet per square mile" means the number of cubic feet of water flowing each second from every square mile of drainage area.

"Depth in inches" means the depth of water in inches that would have covered the drainage area, uniformly distributed, if all the water could have accumulated on the surface. This quantity is used for comparing run-off with rainfall, which quantity is usually given in depth in inches.

It should be noticed that "acre-feet" and "depth in inches" represent the actual quantities of water which are produced during the periods in question, while "second-feet," on the contrary, is merely a rate of flow, into which the element of time does not enter.

The base data for computing the daily discharge of a stream are the various discharge measurements and the daily gage heights, and sufficient discharge measurements should be had to cover the range of gage heights. The fundamental laws upon which these computations are based are the following:

(1) The discharge will remain constant so long as the conditions at or near the gaging station remain constant;

(2) Neglecting the change of slope due to the rise and fall of the stream, the discharge will be the same whenever the stream is at a given stage; and

(3) The discharge is both a function of, and increases gradually with, the gage heights.

As the beds of many streams are changeable, the problem divides itself into two classes: (1) Those of streams with permanent or practically permanent beds, and (2) those of streams with changeable beds. The base data and methods of obtaining them are the same for either class, and it is only in the computation of the mean daily flow that different methods are necessary.

In determining the daily discharge of streams with permanent beds, the results of the discharge measurements are plotted on cross-section paper, with gage heights as ordinates and discharges as abscissas. Through these points a smooth curve is drawn, which shows the discharge for any gage height, and from which a rating table is prepared. The mean velocity and area determined for each discharge measure-

ment are also plotted. Through these points the curves of mean velocity and of area are drawn, and the rating curve is largely determined by taking the product of the mean velocity and the area at various stages as determined by these curves. These curves of mean velocity and area are of special value in determining the location of the rating curve for stages at which actual discharge measurements are not available and for extending the discharge curve outside the limits of the measurements. In the preparation of the rating table the discharge for each tenth or half-tenth on the gage is found from the curve. The first and second differences of these discharges are then taken and adjusted according to the law that they shall either be constant or increasing, never decreasing. The discharges in the table are then changed in accordance with these adjusted differences. In making up the station-rating curve, the individual discharge measurements and the conditions under which they were taken are carefully studied, in order that proper weight shall be given to each measurement. Rating curves in general take the form of a parabola, and as a rule the high-water portion of the curve approaches a straight line. For stations of permanent character, the results of the measurements from year to year should be within 5 per cent of the curve, with the exception of those taken during high water, when the probable error may be as high as 10 per cent.

The determination of the daily discharge of streams with changeable beds is difficult, and unless frequent discharge measurements are made, the results obtained are only roughly approximate. For streams with continually shifting beds, such as Colorado River and Rio Grande, discharge measurements are made every two or three days, and the discharges for the intervening days are obtained by interpolation, modified by the gage heights for these days. For stations with beds which shift slowly, or are only materially changed during floods, station rating curves and tables can be prepared for the periods between changes, and satisfactory results can be obtained with two or three measurements a month, providing measurements are taken soon after the changes occur.

In determining the flow for periods when the streams are frozen, special rating curves and tables have to be prepared from measurements taken under these conditions. The methods of constructing these curves and tables are the same as for open sections. The discharge measurements, however, are taken either by integration in verticals or by vertical velocity-curves, as sufficient experiments have not been made on ice-covered streams to determine the laws which govern the position of the thread of mean velocity.

The Report of Progress of Stream Measurements for the Calendar Year 1904, of which this is Part III, is published in a series of twelve

Water-Supply Papers, Nos. 124–135, inclusive, under the following subtitles:

Part 1. Atlantic coast of New England drainage.
Part 2. Hudson, Passaic, Raritan, and Delaware River drainages.
Part 3. Susquehanna, Patapsco, Potomac, James, Roanoke, Cape Fear, and Yadkin River drainages.
Part 4. Santee, Savannah, Ogeechee, Altamaha rivers, and Eastern Gulf of Mexico drainage.
Part 5. Eastern Mississippi River drainage.
Part 6. Great Lakes and St. Lawrence River drainage.
Part 7. Hudson Bay, Minnesota, Wapsipinicon, Iowa, Des Moines, and Missouri River drainages.
Part 8. Platte, Kansas, Meramec, Arkansas, and Red River drainages.
Part 9. Western Gulf of Mexico drainage.
Part 10. Colorado River and the Great Basin drainage.
Part 11. The Great Basin and Pacific Ocean drainages in California.
Part 12. Columbia River and Puget Sound drainage.

The territory covered by each paper is given in the subtitle, and the larger drainages are, for convenience in arrangement, subdivided into smaller ones, under which the data are arranged, as far as practicable, geographically.

These papers contain the data that have been collected at the regular gaging stations, the results of the computations based upon the observations and such other information that has been collected that has a direct bearing on these data, including, as far as practicable, descriptions of the drainage areas and the streams draining them.

For each regular station are given, as far as available, the following data:

1. Description of station.
2. List of discharge measurements.
3. Gage height table.
4. Rating table.
5. Table of estimated monthly and yearly discharges and run-off.

The descriptions of stations give, as far as possible, such general facts about the locality and equipment as would enable the reader to find the station and use the same. They also give, as far as possible, a complete history of all the changes that have occurred since the establishment of the station that would be factors in using the data collected.

The discharge measurement table gives the results of the discharge measurements made during the year. This includes the date, the hydrographer's name, the gage height, and the discharge in second-feet.

The table of daily gage-heights gives for each day the fluctuations of the surface of the river as found from the mean of the gage readings taken on that day. At most of the stations the gage is read in the morning and in the evening.

The rating table gives discharges in second-feet corresponding to each stage of the river as given by the gage heights.

In the table of estimated run-off the column headed "Maximum" gives the mean flow for the day when the mean gage height was the highest, and it is the flow as given in the rating table for that mean gage height. As the gage height is the mean for the day, there might have been short periods when the water was higher and the corresponding discharge larger than given in this column. Likewise in the column of "Minimum" the quantity given is the mean flow for the day when the mean gage height was lowest. The column headed "Mean" is the average flow for each second during the month. Upon this the computations for the two remaining columns which are defined on page 12 are based.

In the computations for the tables of this report the following general and special rules have been used:

Fundamental rules for computation.

1. The highest degree of precision consistent with the rational use of time and money is imperative.

2. All items of computation should be expressed by at least two and by not more than four significant figures.

3. Any measurement in a vertical velocity, mean velocity, or discharge curve whose per cent of error is 5 times the average per cent error of all the other measurements should be rejected.

4. In reducing the number of significant figures, or the number of decimal places, by dropping the last figure, the following rules apply:

(a) When the figure in the place to be rejected is less than 5, drop it without changing the preceding figure. Example: 1,827.4 becomes 1,827.

(b) When the figure in the place to be rejected is greater than 5, drop it and increase the preceding figure by 1. Example: 1,827.6 becomes 1,828.

(c) When the figure in the place to be rejected is 5, and it is preceded by an even figure, drop the 5. Example: 1,828.5 becomes 1,828.

(d) When the figure in the place to be rejected is 5, and it is preceded by an odd figure, drop the 5 and increase the preceding figure by 1. Example: 1,827.5 becomes 1,828.

5. In constructing and applying rating tables a maximum limit of one-half per cent error should seldom be exceeded.

Special rules for computation.

1. Rating tables are to be constructed as close as the data upon which they are based will warrant. No decimals are to be used when the discharge is over 50 second-feet.

2. Daily discharges shall be applied directly to the gage heights as they are tabulated.

3. Monthly means are to be carried out to one decimal place when the quantities are below 100 second-feet. Between 100 and 10,000 second-feet, the last figure in the monthly mean shall be a significant figure. This also applies to the yearly mean.

4. Second-feet per square mile and depth in inches for the individual months shall be carried out at least to three significant figures, except in the case of decimals, where the first significant figure is preceded by one or more naughts (0), when the quantity shall be carried out to two significant figures. Example: 1.25; .125; .012; .0012. The yearly means for these quantities are always to be expressed in three significant figures and at least two decimal places.

The results of the stream measurements made during previous years by the United States Geological Survey can be found in the following Survey publications. A detailed index of these reports is given in Water-Supply Paper No. 119.

1888. Tenth Annual Report, Part II.
1889. Eleventh Annual Report, Part II.
1890. Twelfth Annual Report, Part II.
1891. Thirteenth Annual Report, Part III.
1892. Fourteenth Annual Report, Part II.
1893. Bulletin No. 131.
1894. Bulletin No. 131; Sixteenth Annual Report, Part II.
1895. Bulletin No. 140.
1896. Water-Supply Paper No. 11; Eighteenth Annual Report, Part IV.
1897. Water-Supply Papers Nos. 15 and 16; Nineteenth Annual Report, Part IV.
1898. Water-Supply Papers Nos. 27 and 28; Twentieth Annual Report, Part IV.
1899. Water-Supply Papers Nos. 35 to 39, inclusive; Twenty-first Annual Report, Part IV.
1900. Water-Supply Papers Nos. 47 to 52, inclusive; Twenty-second Annual Report, Part IV.
1901. East of the Mississippi River, Water-Supply Papers Nos. 65 and 75.
West of the Mississippi River, Water-Supply Papers Nos. 66 and 75.
1902. East of the Mississippi River, Water-Supply Papers Nos. 82 and 83.
West of the Mississippi River, Water-Supply Papers Nos. 84 and 85.
1903. East of the Mississippi River, Water-Supply Papers Nos. 97 and 98.
West of the Mississippi River, Water-Supply Papers Nos. 99 and 100.
1904. East of the Mississippi River, Water-Supply Papers Nos. 124 to 129, inclusive.
West of the Mississippi River, Water-Supply Papers Nos. 130 to 135, inclusive.

A limited number of these are for free distribution, and as long as the supply lasts they may be obtained by application to the Director United States Geological Survey or to members of Congress. Other copies are filed with the Superintendent of Public Documents, Washington, D. C., from whom they may be had at nominal cost. Copies of Government publications are, as a rule, furnished to the public libraries in our large cities, where they may be consulted by those interested.

COOPERATION AND ACKNOWLEDGMENTS.

Most of the measurements presented in this paper have been obtained through local hydrographers. Acknowledgment is extended to other persons and corporations who have assisted local hydrographers or have cooperated in any way, either by furnishing records of the height of water or by assisting in transportation.

The following list, arranged alphabetically by States, gives the names of the resident hydrographers and others who have assisted in furnishing and preparing the data contained in this report:

Maryland.—Resident hydrographer, E. G. Paul during first half and N. C. Grover during the last half of the year, assisted by H. D. Comstock. Acknowledgment is due to the State Geological Survey for cooperation in the work to the extent of paying the observers.

New Jersey.—Resident hydrographer, E. G. Paul during first half and N. C. Grover during the last half of the year, assisted by H. D. Comstock.

Pennsylvania.—Resident hydrographer, E. G. Paul during first half and N. C. Grover during the last half of the year, assisted by R. J. Taylor and H. D. Comstock. Acknowledgments are due to E. Mather, president of the board of water commissioners, and C. M. Nagle, chief engineer, Harrisburg; James F. Fisher, city engineer of Williamsport, Pa., for cooperation in securing gage heights on Susquehanna River, and Dr. Cary T. Hutchinson, for discharge measurements and records of gage height at McCall Ferry.

Virginia.—Resident hydrographer, E. G. Paul during first half and N. C. Grover during the last half of the year. Acknowledgments are due to J. D. Hofford, manager of the Willson Aluminum Company, at Holcomb Rock, Va., for gage heights of James River at that place.

West Virginia.—Resident hydrographer, E. G. Paul in the first half and N. C. Grover in the last half of the year.

SUSQUEHANNA RIVER DRAINAGE BASIN.

Susquehanna River rises in New York and flows southwestward a short distance below the New York-Pennsylvania line, where it turns to the southeast; near Wilkesbarre it again bends to the southwest and flows in this direction as far as Northumberland, where it is joined by the West Branch. Below Northumberland it flows southward and southeastward to Chesapeake Bay. Its total drainage area is about 27,400 square miles, and is larger than that of any other stream on the Atlantic slope of the United States. It is not navigable above the fall line near its mouth.

As the drainage basin embraces such a large area, it is varied in character. In New York the stream, with its tributaries, flows through a rolling and sometimes rather broken country, bounded by a mountainous region on the north. In this part of the course its bed is of gravel or sand, with an occasional rock ledge. Its banks are moderately high and not extensively subject to overflow. In Pennsylvania it enters a mountain region, and its course is in places tortuous as it winds among the parallel ranges. Its bed is generally composed of drift materials, gravel, sand, and bowlders, and its banks are high. Below the mouth of the West Branch the slope becomes more irregular, and at several places there are rapids where the stream flows over a rock bottom. In the lower part of its course, from Marietta to Havre de Grace, the stream occupies a deep, broad valley, varying in width from a few hundred feet to more than a mile. On either shore it is, for the most part, bounded by rocky bluffs and table-lands having elevations from 100 to 500 feet above its waters.

The West Branch has its source in the mountains of Cambria County, Pa., at an elevation of 2,000 feet or more above the sea. It flows generally eastward through Pennsylvania and joins the main stream at Northumberland. Its total drainage area is about 7,030 square miles. In its upper course this tributary drains a mountainous country, while in its middle and lower course the surface is hilly.

Juniata River rises in Center County, Pa., and flows in a southeasterly direction into Susquehanna River 15 miles above Harrisburg. Its drainage basin is mountainous and for the most part covered with forest growth. It has an area of 3,530 square miles.

All available hydrographic data for Susquehanna River basin have been collected and published in Water-Supply Papers 108 and 109. The former of these treats principally of the quality of the water, while the latter gives all data available as to fluctuations in stage and quantity of water flowing.

Water-Supply Paper No. 109 contains records of flow at the gaging stations described in this paper and at the following additional stations:

West Branch at Allenwood, Pa.
Tioughnioga at Chenango Forks, N. Y.
Cayuta at Waverly, N. Y.
Chenango at Oxford, N. Y.
Eaton and Madison brooks at Madison County, N. Y.
Diversions from Chenango River drainage basin.

During 1904 the United States Geological Survey has maintained the following gaging stations in this basin:

Susquehanna at Binghamton, N. Y.
Susquehanna at Wilkesbarre, Pa.
Susquehanna at Danville, Pa.
Susquehanna at Harrisburg, Pa.
Susquehanna at McCall Ferry, Pa.
Chenango at Binghamton, N. Y.
Chemung at Chemung, N. Y.
West Branch at Williamsport, Pa.
Juniata at Newport, Pa.
Broad Creek at Mill Green, Md.
Deer Creek at Churchville, Md.

The United States Weather Bureau maintains river stations in this basin at the following points:

Susquehanna at Towando, Pa.
Susquehanna at Selinsgrove, Pa.
West Branch at Clearfield, Pa.
West Branch at Lock Haven, Pa.
Juniata at Huntingdon, Pa.

SUSQUEHANNA RIVER AT BINGHAMTON, N. Y.

This gaging station was established July 31, 1901. A standard chain gage is attached to the upstream side of the left span of the Washington Street Bridge, which is situated about 800 feet upstream

from the junction of Chenango and Susquehanna rivers. On account of the unfavorable conditions produced by a rift, which extends diagonally across the stream underneath the bridge, discharge measurements are made at Exchange Street Bridge, 1,900 feet upstream. The gage is upstream from the crest of the rift and over a stretch of smooth water extending to the dam, 2,800 feet above. Gage readings are unaffected by backwater from Chenango River at ordinary stages. The bench mark is a chiseled draft on the corner of the left bridge abutment, on the upstream side. Its elevation is 23.71 feet above gage datum. The gage is read twice each day by E. F. Weeks. All records and estimates for this station for years prior to 1905 have been revised and republished in Water-Supply Paper No. 109.

The observations at this station during 1904 have been made under the direction of R. E. Horton, district hydrographer.

Discharge measurements of Susquehanna River at Binghamton, N. Y., in 1904.

Date.	Hydrogra	Area of section.	Mean velocity.	Gage height.	Discharge.
		Sq. feet.	*Ft. per sec.*	*Feet.*	*Second-feet.*
March 8	C. C. Covert	3,975	3.58	[a] 11.24	14,254
March 12	do	2,846	2.60	[a] 7.90	7,400
April 8	R. E. Horton	2,524	4.50	6.94	11,118
July 13	C. C. Covert	736	1.07	2.04	786
September 10	do	825	1.29	2.13	1,061
November 21	H. R. Beebe	1,011	2.64	2.86	2,674

[a] Ice gorge causes backwater.

Mean daily gage height, in feet, of Susquehanna River at Binghamton, N. Y., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.28	3.67	3.57	7.72	5.06	2.46	2.02	2.40	2.28	4.12	3.08	2.98
2	3.35	3.40	3.29	9.02	4.53	2.48	1.99	2.35	2.25	3.35	3.00	2.82
3	[a] 3.42	3.59	3.92	8.00	4.08	2.38	2.14	2.98	2.28	2.90	2.92	2.85
4	3.88	3.67	[b] 6.65	6.95	3.68	2.36	2.14	2.95	2.28	2.80	2.88	2.70
5	3.52	3.55	8.48	6.20	3.51	2.38	2.06	2.60	2.20	2.68	2.82	2.85
6	3.58	3.15	7.68	6.15	3.33	2.41	2.09	3.52	2.22	2.62	2.80	2.68
7	3.30	4.42	7.52	6.35	3.13	2.46	2.04	3.40	2.28	2.62	2.92	2.68
8	3.28	10.49	11.40	6.98	2.98	2.57	2.04	2.72	2.22	2.52	2.90	2.60
9	3.15	11.92	13.62	7.14	2.86	3.67	2.04	2.50	2.22	2.45	2.80	2.60
10	3.20	10.85	12.25	8.74	2.80	4.23	2.04	2.38	2.20	2.42	2.75	2.68
11	3.10	8.62	9.80	8.24	2.69	3.43	2.04	2.50	2.18	2.40	2.75	2.58
12	2.98	7.15	8.02	6.94	2.65	2.93	1.99	2.45	2.18	2.88	2.75	2.98
13	2.78	6.03	6.88	6.09	2.65	2.65	2.04	2.30	2.20	5.60	2.70	2.50
14	2.72	5.27	6.08	5.51	2.49	2.50	2.02	2.22	2.15	4.68	2.70	2.58
15	2.85	4.77	5.30	4.97	2.59	2.43	1.95	2.20	3.00	3.65	2.68	2.58
16	3.05	6.12	4.75	4.61	3.22	2.45	1.92	2.28	3.10	3.45	2.70	2.58
17	2.85	[b] 6.85	4.28	4.49	3.45	2.33	2.05	2.22	2.82	2.95	2.78	2.60

[a] Anchor ice. January 6, river frozen nearly across.
[b] Heavy anchor ice. River frozen over 2,000 feet downstream from junction of the two rivers. Ice gorge causes backwater March 4–15.

Mean daily gage height, in feet, of Susquehanna River at Binghamton, N. Y., for 1904—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug	Sept.	Oct.	Nov.	Dec.
18	3.00	6.07	3.85	4.39	3.17	2.33	2.28	2.18	2.55	2.80	2.75	2.48
19	2.98	5.67	3.55	4.49	2.92	2.23	2.10	2.18	2.42	2.70	2.65	2.40
20	3.08	5.22	3.92	4.37	3.22	2.17	2.05	2.22	2.35	2.62	2.65	2.30
21	3.80	4.72	4.45	4.17	3.05	2.20	1.98	2.90	2.30	5.95	2.82	2.45
22	2.78	4.52	4.30	3.97	2.75	2.13	2.00	3.18	2.30	7.48	3.58	2.78
23	7.02	4.92	7.42	3.97	2.67	2.14	1.98	4.55	2.28	6.95	3.72	2.40
24	7.82	5.72	11.40	3.77	2.59	2.09	2.00	4.20	2.18	5.32	3.55	2.55
25	[a] 8.27	5.52	12.12	3.79	2.62	2.06	2.02	3.38	3.52	4.40	3.38	3.08
26	6.85	4.67	15.92	3.96	2.52	2.02	2.02	2.92	3.25	4.40	3.32	3.15
27	5.95	4.19	15.70	3.93	2.49	1.99	2.05	2.78	3.22	4.35	3.18	3.40
28	5.25	3.75	12.62	[b] 5.83	2.45	1.99	2.52	2.63	2.85	3.92	2.90	8.80
29	4.42	3.67	8.50	6.36	2.36	2.04	2.58	2.48	2.65	3.65	2.78	9.60
30	4.27	.....	6.90	5.63	2.36	1.99	3.12	2.38	2.80	3.42	2.88	7.05
31	3.89	.....	6.72	.....	2.36	.....	2.65	2.35	.....	3.18	.....	5.25

[a] Current of stream very sluggish. [b] Backwater from Chenango River.

Rating table for Susquehanna River at Binghamton, N. Y., for 1901 to 1904, inclusive.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.75	210	3.9	5,255	7.2	15,260	11.6	30,860
1.8	315	4.0	5,510	7.4	15,920	11.8	31,580
1.9	525	4.1	5,770	7.6	16,590	12.0	32,300
2.0	740	4.2	6,030	7.8	17,270	12.2	33,020
2.1	960	4.3	6,300	8.0	17,950	12.4	33,740
2.2	1,180	4.4	6,570	8.2	18,650	12.6	34,470
2.3	1,400	4.5	6,845	8.4	19,350	12.8	35,210
2.4	1,625	4.6	7,125	8.6	20,060	13.0	35,950
2.5	1,855	4.7	7,405	8.8	20,780	13.5	37,820
2.6	2,085	4.8	7,690	9.0	21,500	14.0	39,720
2.7	2,315	4.9	7,980	9.2	22,220	14.5	41,650
2.8	2,545	5.0	8,280	9.4	22,940	15.0	43,600
2.9	2,785	5.2	8,880	9.6	23,660	15.5	45,550
3.0	3,025	5.4	9,495	9.8	24,380	16.0	47,500
3.1	3,265	5.6	10,120	10.0	25,100	16.5	49,500
3.2	3,505	5.8	10,760	10.2	25,820	17.0	51,500
3.3	3,755	6.0	11,400	10.4	26,540	17.5	53,500
3.4	4,005	6.2	12,040	10.6	27,260	18.0	55,500
3.5	4,255	6.4	12,680	10.8	27,980	18.5	57,500
3.6	4,505	6.6	13,320	11.0	28,700	19.0	59,500
3.7	4,755	6.8	13,960	11.2	29,420	19.5	61,500
3.8	5,005	7.0	14,600	11.4	30,140	20.0	63,500

Mean daily discharge, in second-feet, of Susquehanna River at Binghamton, N. Y., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3,705	4,680	4,430	16,930	8,430	1,763	784	1,625	1,356	5,770	3,217	2,977
2	3,880	4,005	3,730	21,500	6,985	1,809	718	1,510	1,290	3,880	3,025	2,593
3	4,055	4,480	5,305	17,950	5,770	1,579	1,048	2,977	1,356	2,785	2,833	2,665
4	5,205	4,680	6,740	14,440	4,705	1,532	1,048	2,905	1,356	2,545	2,737	2,315
5	4,305	4,380	9,815	12,040	4,280	1,579	872	2,085	1,180	2,269	2,593	2,665
6	4,455	3,385	8,410	11,880	3,830	1,648	938	4,305	1,224	2,131	2,545	2,269
7	3,755	6,624	10,100	12,520	3,337	1,763	828	4,005	1,356	2,131	2,833	2,269
8	3,705	26,864	15,070	14,600	2,977	2,016	828	2,361	1,224	1,901	2,785	2,085
9	3,385	32,012	19,100	15,095	2,689	4,680	828	1,855	1,224	1,740	2,545	2,085
10	3,505	28,160	16,600	20,600	2,545	6,165	828	1,579	1,180	1,671	2,430	2,269
11	3,265	20,132	12,190	18,825	2,292	4,080	828	1,855	1,136	1,625	2,430	2,039
12	2,977	15,095	8,970	14,440	2,200	2,857	718	1,740	1,136	2,737	2,430	2,977
13	2,499	11,688	7,140	11,720	2,200	2,200	828	1,400	1,180	10,120	2,315	1,855
14	2,361	9,092	5,860	9,805	1,832	1,855	784	1,224	1,070	7,405	2,315	2,039
15	2,665	7,603	5,000	8,130	2,062	1,694	630	1,180	3,025	4,630	2,269	2,039
16	3,145	11,784	7,545	7,125	3,555	1,740	567	1,356	3,265	4,130	2,315	2,039
17	2,665	14,120	6,300	6,845	4,130	1,466	850	1,224	2,593	2,905	2,499	2,085
18	3,025	11,624	5,130	6,570	3,433	1,466	1,356	1,136	1,970	2,545	2,430	1,809
19	2,977	10,344	4,380	6,845	2,833	1,246	960	1,136	1,671	2,315	2,200	2,085
20	3,217	8,940	5,305	6,435	3,555	1,114	850	1,224	1,510	2,131	2,200	1,625
21	5,005	7,461	6,705	5,900	3,145	1,180	696	2,785	1,400	11,240	2,593	1,740
22	2,499	6,901	6,300	5,432	2,430	1,026	740	3,457	1,400	16,250	4,455	2,039
23	14,666	8,040	15,920	5,432	2,246	1,048	696	6,985	1,356	14,440	4,805	1,625
24	17,338	10,504	30,140	4,930	2,062	938	740	6,030	1,136	9,185	4,380	1,970
25	18,895	9,867	32,660	4,980	2,131	872	784	3,965	4,305	6,570	3,955	3,217
26	14,120	7,321	47,110	5,406	1,901	784	784	2,833	3,630	6,570	3,805	3,385
27	11,240	6,004	46,330	5,330	1,832	718	850	2,499	3,555	6,435	3,457	4,005
28	9,030	4,880	34,470	5,080	1,740	718	1,901	2,154	2,665	5,305	2,785	20,780
29	6,624	4,680	19,700	12,520	1,532	828	2,039	1,809	2,200	4,630	2,499	23,660
30	6,219	.....	14,280	10,280	1,532	718	3,313	1,579	2,545	4,055	2,737	14,765
31	5,230	.....	13,640	.....	1,532	.....	2,200	1,510	.....	3,457	.....	9,034

NOTE.—On account of backwater from Chenango River and ice gorges, the discharges from March 4 to 15 and on April 28 are uncertain, and are only estimates.

Estimated monthly discharge of Susquehanna River at Binghamton, N. Y., for 1904.

[Drainage area, 2,400 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches
January	18,895	2,361	5,794	2.41	2.78
February	32,012	3,385	10,530	4.39	4.73
March	47,110	3,730	14,010	5.84	6.73
April	21,500	4,930	10,650	4.44	4.95
May	8,430	1,532	3,088	1.29	1.49
June	6,165	718	1,769	.737	.822
July	3,313	567	1,027	.428	.493
August	6,985	1,136	2,396	.998	1.151
September	4,305	1,070	1,850	.770	.859
October	16,250	1,625	5,016	2.09	2.41
November	4,805	2,200	2,881	1.20	1.34
December	23,660	1,625	4,226	1.76	2.03
The year	47,110	567	5,270	2.20	29.78

SUSQUEHANNA RIVER AT WILKESBARRE, PA.

This gaging station was established by E. G. Paul, March 30, 1899. The standard chain gage is attached to the upstream side of the left span of Market Street Bridge. The length of the chain from the end of the weight to the marker is 40.83 feet. The bench mark is the extreme west end of the stone doorsill of the north entrance to the Coal Exchange Building. Its elevation is 32.99 feet above gage datum.

The Weather Bureau has maintained a gage and has records for this locality since 1888. The datum of that Bureau's gage, which was attached to the left-hand pier, was at the bottom of the dressed-stone portion of the pier, at an elevation reported to be 535 feet above sea level. During low stages of the river the water recedes from the pier, rendering it impracticable to read this gage. On account of the low water, which in 1897 had gone below the city datum, it was decided to put the zero of the new gage 4 feet below the zero of the old Weather Bureau gage, so as to obviate minus readings. In order, therefore, to compare with former records it is necessary to add 4 feet to the old figures. The danger mark of this Weather Bureau gage is at 14 feet (or 18 feet on new gage), as at this elevation the west bank of the river is under water in places.

Discharge measurements are made from the downstream side of the

bridge, which has a total span of 700 feet between abutments. The initial point for soundings is at the end of the iron hand rail on the left bank, downstream side. The channel is straight for about one-fourth mile above and below the station. There is a bar across the river about one-half mile above the station, and another at about the same distance below, with deep water between these two points. The current is sluggish at low stages. The right bank is low and overflows at a gage height of about 20 feet. The left bank is above ordinary floods. The bed of the stream is composed of sand and gravel, and is somewhat shifting. There is but one channel, broken by three bridge piers. A few willows grow under the right span. During low water, measurements have been made by wading at a better cross section, at Retreat, 10 miles below Wilkesbarre. The Market Street Bridge is at such an elevation above the river bed that 65 feet of cable is needed to sound across the section.

Since the establishment of this station the recorded gage height has had a maximum range of 28.5 feet, and the estimated discharge has been between the extremes of 146,800 and 1,000 cubic feet per second. All records and estimates for this station for years prior to 1905 have been revised and republished in Water-Supply Paper No. 109. The gage is read once each day by W. S. Bennett, the bridge keeper.

Observations of fluctuations of Susquehanna River are made by the Weather Bureau above Wilkesbarre, at Towanda, Pa., where the drainage area is estimated to be 8,000 square miles. The river gage, made of iron, 1 foot wide and one-half inch thick, is on the east side of the road bridge over Susquehanna River, and is securely bolted to the masonry of the pier. The graduation is from 0 to 25 feet. The highest water was 29 feet, in March, 1869, and the lowest, −0.1 foot, in October, 1895; the danger line is at 16 feet. The elevation of the zero is 633.7 feet above sea level.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Susquehanna River at Wilkesbarre, Pa., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Sq. feet.	*Ft. per sec.*	*Feet.*	*Second-ft.*
July 20	N. C. Grover	3,864	1.13	4.05	4,382
July 21[a]	do	4,077	1.15	4.20	4,680
September 15	John C. Hoyt	3,670	.96	3.70	3,540
October 1	do	4,220	1.44	4.75	6,090
November 5	H. D. Comstock	4,218	1.47	4.61	6,189
November 7	do	4,057	1.39	4.49	5,660

[a] Measured at Pittston.

Mean daily gage height, in feet, of Susquehanna River at Wilkesbarre, Pa., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	9.00	14.00	10.80	12.00	11.50	5.70	3.50	4.80	3.70	4.80	5.30	4.30
2	8.90	13.00	10.90	15.10	10.50	7.40	3.50	4.40	3.60	5.40	5.10	4.10
3	8.50	12.30	11.50	15.80	9.40	7.00	3.50	4.20	3.50	5.90	4.90	4.20
4	7.20	11.60	16.50	14.00	8.40	6.40	3.50	4.30	3.40	5.20	4.80	4.20
5	6.50	11.00	a 18.20	12.00	7.60	6.00	3.50	5.30	3.40	4.70	4.60	3.80
6	6.70	b 10.90	17.20	10.70	7.00	9.10	3.50	5.00	3.30	4.50	4.50	3.70
7	7.20	11.60	17.90	10.20	6.70	7.40	3.60	4.40	3.30	4.30	4.50	3.50
8	7.20	c 21.70	25.20	10.50	6.30	6.40	3.70	4.60	3.30	4.00	4.50	3.60
9	7.30	25.30	d 30.60	11.00	6.00	6.60	4.20	5.00	3.50	4.00	4.50	3.80
10	7.40	24.60	26.60	11.70	5.70	11.60	3.80	4.40	3.50	3.90	4.50	3.20
11	7.30	23.80	24.00	16.20	5.50	10.90	3.70	4.60	3.30	3.80	4.40	3.10
12	7.10	22.00	e 22.00	14.30	5.20	8.50	4.10	4.00	3.30	3.80	4.40	3.30
13	7.00	20.30	e 19.30	12.10	5.00	7.10	4.50	3.90	3.20	3.90	4.30	3.20
14	7.00	f 18.00	e 17.40	10.80	4.80	6.20	4.20	3.80	3.10	7.00	4.20	3.30
15	6.70	17.00	e 15.90	9.70	4.80	5.60	3.90	3.60	3.60	8.30	4.30	3.50
16	6.40	15.70	e 14.90	8.90	6.10	5.20	3.80	3.50	5.50	6.90	4.30	3.30
17	6.20	14.70	e 14.00	8.30	8.00	5.10	3.60	3.40	4.30	6.00	4.30	3.30
18	6.00	12.90	e 13.00	8.00	7.90	5.60	3.90	3.30	4.80	5.50	4.40	3.30
19	g 5.90	12.60	e 12.50	7.90	7.10	4.80	3.60	3.30	4.40	5.10	4.30	3.30
20	5.60	h 12.90	12.80	7.90	11.20	4.50	3.70	3.20	4.10	4.80	4.30	3.30
21	i 5.60	12.70	13.60	7.80	10.20	4.30	4.20	3.20	3.80	5.00	4.30	3.40
22	6.00	12.90	10.50	7.40	8.50	4.10	3.80	3.30	3.60	8.60	4.60	3.40
23	12.70	13.70	9.70	7.10	7.30	4.30	3.50	3.70	3.40	10.20	4.60	3.30
24	j 18.20	12.80	16.90	7.10	6.50	4.00	3.40	4.90	3.40	10.20	5.30	3.50
25	13.50	12.70	16.30	7.00	6.50	3.90	3.30	6.40	3.40	8.80	5.50	3.60
26	k 11.60	12.60	20.40	6.90	6.70	3.80	3.40	5.80	4.00	7.40	5.20	3.30
27	k 10.10	12.00	22.90	7.20	6.50	3.70	3.70	5.30	5.40	6.90	5.00	3.50
28	k 9.00	12.00	22.70	7.90	5.90	3.50	3.60	4.60	5.30	6.70	4.80	10.00
29	k 8.20	11.50	18.40	12.40	6.00	3.50	3.60	4.30	5.20	6.40	4.20	13.45
30	k 9.20	.....	14.20	12.80	5.50	3.40	3.80	4.10	4.70	6.00	4.20	13.30
31	13.90	.....	11.70	.....	5.30	.....	4.10	3.90	.....	5.90	.....	10.80

a Ice still unbroken.
b Closed with anchor ice as far up as Ransom.
c Ice started at 5.15 p. m.; moved until Februa y 10, 12 m. Gorged below city.
d Highest gage reading 30.60.
e Still gorged.
f Ice blocked as far as Tunkhannock, Pa.
g Ice started at Pittston at 1.30 p. m., at Wilkesbarre, 2 p. m. River closed December 10 to 28, inclusive.
h Ice blocked as far as Laceyville, Pa.
i 12 midnight, ice still running; stream nearly full.
j River full of running ice all day; 10 p. m., very little ice running.
k Anchor ice.

Rating table for Susquehanna River at Wilkesbarre, Pa., from March 30, 1899, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.0	620	4.3	5,070	6.6	13,170	9.8	28,200
2.1	720	4.4	5,340	6.7	13,590	10.0	29,200
2.2	820	4.5	5,620	6.8	14,010	10.2	30,100
2.3	930	4.6	5,910	6.9	14,440	10.4	31,100
2.4	1,050	4.7	6,210	7.0	14,870	10.6	32,100
2.5	1,180	4.8	6,520	7.1	15,300	10.8	33,000
2.6	1,320	4.9	6,830	7.2	15,730	11.0	34,000
2.7	1,470	5.0	7,150	7.3	16,160	11.2	35,000
2.8	1,630	5.1	7,470	7.4	16,600	11.4	36,000
2.9	1,810	5.2	7,800	7.5	17,040	11.6	37,000
3.0	2,000	5.3	8,140	7.6	17,490	11.8	37,900
3.1	2,200	5.4	8,490	7.7	17,950	12.0	38,900
3.2	2,410	5.5	8,850	7.8	18,420	12.2	39,900
3.3	2,620	5.6	9,210	7.9	18,900	12.4	40,800
3.4	2,840	5.7	9,580	8.0	19,380	12.6	41,800
3.5	3,070	5.8	9,950	8.2	20,360	12.8	42,800
3.6	3,300	5.9	10,330	8.4	21,340	13.0	43,700
3.7	3,540	6.0	10,720	8.6	22,320	13.2	44,700
3.8	3,780	6.1	11,120	8.8	23,300	13.4	45,700
3.9	4,030	6.2	11,520	9.0	24,300	13.6	46,700
4.0	4,280	6.3	11,930	9.2	25,300	13.8	47,600
4.1	4,540	6.4	12,340	9.4	26,200	14.0	48,600
4.2	4,800	6.5	12,750	9.6	27,200		

Table based on discharge measurements of 1899, 1900, 1901, 1902, 1903, and 1904. Well defined between 2 feet gage height and 19 feet gage height. Tangent at 8.80 feet gage height with a difference of 500 per tenth. Table applied to tenths.

Mean daily discharge, in second-feet, of Susquehanna River at Wilkesbarre, Pa., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	24,300	48,600	16,600	38,900	36,500	9,580	3,070	6,520	3,540	6,520	8,140	4,8[illegible]
2	23,800	43,700	16,900	56,000	31,600	16,600	3,070	5,340	3,300	8,490	7,470	4,5[illegible]
3	21,830	40,300	18,350	61,000	26,200	14,870	3,070	4,800	3,070	10,330	6,830	4,8[illegible]
4	15,730	37,000	33,300	48,600	21,340	12,340	3,070	5,070	2,840	7,800	6,520	4,8[illegible]
5	12,750	34,000	40,100	38,900	17,490	10,720	3,070	8,140	2,840	6,210	5,910	5,[illegible]
6	13,590	33,500	36,100	32,600	14,870	24,800	3,070	7,150	2,620	5,620	5,620	2,[illegible]
7	15,730	37,000	38,900	30,100	13,590	16,600	3,300	5,340	2,620	5,070	5,620	3,0[illegible]
8	15,730	55,900	74,760	31,600	11,930	12,340	3,540	5,910	2,620	4,280	5,620	3,3[illegible]
9	16,160	75,100	108,700	34,000	10,720	13,170	4,800	7,150	3,070	4,280	5,620	2,6[illegible]
10	16,600	71,300	82,900	37,400	9,580	37,000	3,780	5,340	3,070	4,030	5,620	2,4[illegible]
11	16,160	67,000	68,000	63,900	8,850	33,500	3,540	5,910	2,620	3,780	5,340	2,2[illegible]
12	15,300	57,600	57,600	50,600	7,800	21,830	4,540	4,280	2,620	3,780	5,340	2,6[illegible]
13	14,870	49,400	44,900	39,400	7,150	15,300	5,620	4,030	2,410	4,030	5,070	2,4[illegible]
14	14,870	39,300	36,800	33,000	6,520	11,520	4,800	3,780	2,200	14,870	4,800	2,6[illegible]
15	13,590	35,300	31,100	27,700	6,520	9,210	4,030	3,300	3,300	20,850	5,070	2,4[illegible]
16	12,340	30,350	27,500	23,800	11,120	7,800	3,780	3,070	8,850	14,440	5,070	2,[illegible]
17	11,520	26,800	31,000	20,850	19,380	7,470	3,300	2,840	5,070	10,720	5,070	2,6[illegible]
18	10,720	21,850	30,000	19,380	18,900	9,210	4,030	2,620	6,520	8,850	5,340	2,6[illegible]
19	10,330	21,050	35,500	18,900	15,300	6,520	3,300	2,620	5,340	7,470	5,070	2,6[illegible]
20	9,210	21,850	42,800	18,900	35,000	5,620	3,540	2,410	4,540	6,520	5,070	2,8[illegible]
21	9,210	21,350	46,700	18,420	30,100	5,070	4,800	2,410	3,780	7,150	5,070	2,8[illegible]
22	10,720	21,850	31,600	16,600	21,830	4,540	3,780	2,620	3,300	22,320	5,910	2,8[illegible]
23	42,300	28,700	27,700	15,300	16,160	5,070	3,070	3,540	2,840	30,100	5,910	2,6[illegible]
24	79,600	21,550	69,200	15,300	12,750	4,280	2,840	6,830	2,840	30,100	8,140	3,0[illegible]
25	46,200	21,350	69,200	14,870	12,750	4,030	2,620	12,340	2,840	23,300	8,850	3,3[illegible]
26	37,000	21,500	98,900	14,440	13,590	3,780	2,840	9,950	4,280	16,600	7,800	2,6[illegible]
27	29,600	19,600	123,400	15,730	12,750	3,540	3,540	8,140	8,490	14,440	7,150	3,0[illegible]
28	24,300	19,600	121,300	18,900	10,330	3,070	3,300	5,910	8,140	13,590	6,520	29,300
29	20,360	18,350	81,300	40,800	10,720	3,070	3,300	5,070	7,800	12,340	4,800	47,8[illegible]
30	25,300	.....	49,900	42,800	8,850	2,840	3,780	4,540	6,210	10,720	4,800	45,2[illegible]
31	48,100	.....	37,400	.....	8,140	.....	4,540	4,030	.....	10,330	.....	38,300

From February 8 to March 19, 1904, discharges reduced 50 per cent on account of ice gorge.

Estimated monthly discharge of Susquehanna River at Wilkesbarre, Pa., for 1904.

[Drainage area, 9,810 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	79,600	9,210	21,860	2.23	2.57
February	75,100	18,350	35,720	3.64	3.92
March	123,400	16,600	52,530	5.34	6.16
April	63,900	14,440	31,290	3.19	3.56
May	36,500	6,520	15,750	1.61	1.86
June	37,000	2,840	11,180	1.14	1.27
July	5,620	2,620	3,636	.371	.428
August	12,340	2,410	5,194	.529	.610
September	8,850	2,200	4,119	.420	.469
October	30,100	3,780	11,260	1.15	1.33
November	8,850	4,800	5,972	.609	.679
December	47,850	2,200	7,660	.781	.900
The year	123,400	2,200	17,180	1.75	23.76

SUSQUEHANNA RIVER AT DANVILLE, PA.

This station, 52 miles below Wilkesbarre and 11 miles above the mouth of the West Branch, was established on March 25, 1899, by E. G. Paul. It is located at Mill Street Bridge, 600 feet south of the public square, Danville, Pa., near the Pennsylvania Railroad station, South Danville.

On March 9, 1904, this bridge was carried away in the ice freshet, and from that date until the water dropped below gage height, 5 feet, its stage was observed on the Weather-Bureau gage, which is painted on the pier nearest the right bank. After the water fell below 5 feet, until September 30, its stage was observed approximately by means of temporary gages, which were placed in position by the gage reader, near the pumping station on the right bank. These were usually set by means of a carpenter's level and at times were considerably in error.

It is expected that the new steel bridge will be in such condition that the chain gage may be replaced early in 1905. The total span is about 1,300 feet, broken by six bridge piers, which do not obstruct the flow to any considerable extent. The channel is straight for about one-half mile above and below the station. The right bank is liable to overflow in extreme freshets. The bed is rocky, with some gravel, and is permanent. The current is good, except at extreme low water.

Since the establishment of the gage the record shows a range in

gage height of nearly 25 feet, and the extremes of high and low water within that period are estimated at 163,000 and 830 cubic feet per second, respectively. The bench mark is the extreme south end of the stone doorsill at the east entrance to the city filtering plant. Its elevation is 31.7 feet above gage datum. All records and estimates for this station for years prior to 1905 have been revised and republished in Water-Supply Paper No. 109.

Observations at this station during 1904 have been under the direction of N. C. Grover, district hydrographer.

Mean daily gage height, in feet, of Susquehanna River at Danville, Pa., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	(a)	14.70	11.40	11.05	8.10	4.00	2.00	2.40	1.90			
2	(a)	14.10	11.30	10.85	8.00	4.20	2.00	2.50	1.90			
3	(a)	13.30	11.80	10.60	7.50	4.70	1.90	2.50	1.80			
4	(a)	12.70	g12.90	10.40	6.40	4.20	1.90	2.70	1.70			
5	(a)	12.10	13.80	10.40	5.30	4.70	1.80	2.90	1.70			
6	(a)	11.70	16.00	9.70	4.20	5.10	2.40	2.50	1.60			
7	(a)	11.50	17.25	9.30	3.70	5.50	2.30	2.40	1.50			
8	(a)	13.10	19.95	8.80	3.60	4.70	2.10	2.70	1.50			
9	(a)	d20.00	h24.00	8.20	3.60	4.30	2.10	2.90	1.40			
10	(a)	e23.86	.....	7.90	3.40	4.90	2.00	2.40	1.40			
11	(a)	21.25	.....	7.40	3.30	7.10	1.90	1.90	1.40			
12	(a)	19.50	.....	6.80	3.30	6.20	1.90	1.70	1.30			
13	(a)	18.05	.....	6.30	3.20	4.80	2.00	1.70	1.30			
14	(a)	16.90	.....	6.10	3.10	4.70	2.40	1.60	1.60			
15	(a)	15.40	.....	5.80	2.90	4.50	2.60	1.60	1.90			
16	(a)	f13.90	.....	5.40	2.70	4.30	2.20	1.50	2.20			
17	(a)	13.00	.....	5.00	3.90	4.00	1.90	1.40	1.90			
18	(a)	12.40	.....	4.70	4.50	3.70	1.80	1.70	1.70			
19	(a)	11.00	.....	4.30	6.30	3.30	1.80	1.60	1.60			
20	(a)	10.60	.....	4.10	6.90	3.00	1.70	1.50	1.50			
21	(a)	11.20	.....	4.00	7.20	2.80	1.70	1.50	1.50			
22	(c)	12.30	.....	3.70	6.30	2.60	1.60	1.40	1.90			
23	(a)	12.30	.....	3.50	4.90	2.60	1.90	1.40	2.40			
24	b19.85	12.40	.....	3.30	4.40	2.50	2.00	1.80	2.90			
25	c24.00	12.00	.....	3.30	4.10	2.50	1.80	2.40	2.30			
26	23.25	11.70	.....	3.20	4.70	2.30	1.70	2.90	2.00			
27	19.85	11.70	14.25	3.00	4.40	2.20	1.50	2.60	2.20			
28	17.90	11.40	13.80	4.20	3.90	2.20	1.80	2.50	2.70			
29	16.00	11.10	13.35	5.30	3.70	2.10	1.80	2.30	2.10			
30	15.55	.....	12.55	6.90	3.70	2.10	2.00	2.00	2.40			
31	15.05	.....	11.75	.....	3.90	.....	2.20	1.90	.....			

a River frozen.
b The ice started at 11.30 a. m.
c The ice gorged 1 p. m.
d The river is still frozen over.
e The ice broke and gorged and left an open place by the bridge.
f The ice is still gorged in the river.
g The ice gorge is still in the river above and below town.
h The ice started at 4 o'clock and the water backed up to 29 feet.

NOTE.—The gage heights for 1904 are somewhat uncertain, therefore no estimates of flow have been made.

SUSQUEHANNA RIVER AT HARRISBURG, PA.

In 1890 regular daily observations of the stage of Susquehanna River at Harrisburg were started by E. Mather, president of the Harrisburg Water Board. These observations have been continued since that time, and have been furnished to the United States Geolgical Survey through the courtesy of Mr. Mather.

The gage is located in the pump well at the pump house of the city waterworks, the well being connected with the river by two large mains. The datum of the gage is the low-water mark of 1803, and is marked on a large, sloping rock, about 40 feet from the left bank at low water and about halfway between the Walnut Street Bridge and the pumping station. The original readings are taken in feet and inches, and for convenience in computations have been reduced to feet and tenths.

The first discharge measurement was made at this station in March, 1897, by Mr. E. G. Paul, and measurements have been made here by engineers of the United States Geological Survey since that date. The measuring section is at the lower side of the Walnut street toll bridge, at which point the river is divided into two channels by Fosters Island, which is here about 1,200 feet wide. This island has low and sloping banks, and during extreme floods is completely overflowed.

At ordinary stages the left channel is 1,350 feet wide, broken by six bridge piers; the right channel is 1,300 feet wide, broken by seven piers. The banks of the river are high. The bed is composed of hard material and is permanent, except in the spans adjacent to the island. The velocity never becomes too sluggish to measure. The initial point for soundings is the upright at the end of the handrail on the downstream side at the left bank.

During the spring and summer of 1903 a new bridge was built across Susquehanna River at Market street, which is about 1,200 feet below the gaging station. The piers of this new bridge obstruct the channel of the river by between 10 and 15 per cent of the total cross section. In the latter part of 1903 and early in 1904 the old piers on this site were removed, so that the river channel was left in such condition that the effect on the stage of the river at Walnut Street Bridge remained practically unchanged.

In the summer of 1904 certain changes and improvements were made at the pumping station, and a partial dam was made in the river just below the pumping station. The effect of this dam was to raise the apparent stage of the water at the gage.

On July 18, 1904, a standard chain gage was attached to the guard rail on the upstream side of Walnut Street Bridge in the left-hand span. The datum of this gage is also the low-water mark of 1803, and it is believed that it records truly the stage of the river to that datum,

and that the changes in bridges below or in the pumping station above do not appreciably affect the records obtained from it.

The length of chain is 39.38 feet. The datum is referred to a bench mark on the left abutment at the top upstream outer corner of the bridge seat; elevation, 32.99 feet.

Observations at the gage in the pumping station are made by the engineer, C. M. Nagle, each morning before starting the pumps. Observations at the standard chain gage are made by Thomas Numbers, toll collector, once daily. All records and estimates for this station for years prior to 1905 have been revised and republished in Water Supply Paper No. 109.

Observations at this station during 1904 have been under the direction of N. C. Grover, district hydrographer.

Minimum, maximum, and mean discharge of Susquehanna River at Harrisburg, Pa., for 1891 to 1904, inclusive.

Year.	Minimum.			Maximum.			Mean discharge.
	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	
		Feet.	*Sec.-feet.*		*Feet.*	*Sec.-feet.*	*Sec.-feet.*
1891	Oct. 4–7, inclusive.	1.60	10,200	Feb. 19	19.00	334,500	52,200
1892	Oct. 31–Nov. 8, inclusive.	.50	4,070	Apr. 6	14.65	224,200	37,250
1893	Aug. 16–19, inclusive, 25.	.35	3,500	May 6	16.50	267,400	40,550
1894	Sept. 5–6	.25	3,160	May 22	25.60	543,500	39,970
1895	Oct. 30–31	.05	2,570	Apr. 11	13.65	205,400	29,330
1896	Sept. 5–13	.25	3,160	Apr. 1–2	14.60	223,200	34,600
1897	Sept. 15, Oct. 21	.50	4,070	Mar. 26	11.50	165,308	32,320
1898	Oct. 3–7	.65	4,740	Mar. 24	15.65	245,900	40,490
1899	Oct. 24 and 25	.15	2,850	Mar. 7	13.00	193,000	31,000
1900	Sept. 28 and 29	—.04	2,360	Mar. 2	13.10	194,900	29,950
1901	Nov. 12	1.00	6,550	Dec. 16	21.40	405,100	42,380
1902	Sept. 23, 24, 25	.85	5,760	Mar. 2	23.90	484,100	47,100
1903	Oct. 7	1.40	8,850	....do ...	16.85	276,500	54,510
1904	.....	0.84	5,708	.....	.....	.....	32,318
For the 14 years.	Sept. 28–29, 1900	—.04	2,360	May 22, 1894.	25.60	543,500	38,855

Discharge measurements of Susquehanna River at Harrisburg, Pa., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Sq. feet.	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
March 9	Tillinghast and Sawyer	40,670	6.2	15.6	[a]261,860
July 15	N. C. Grover	11,870	2.22	3.08	26,408
September 13	J. C. Hoyt	6,646	.90	1.10	5,950
September 29	do	8,730	1.34	1.78	11,660
October 1	N. C. Grover	8,460	1.48	1.85	12,560
November 4	Hoyt and Comstock	8,972	1.39	1.82	12,600

[a] River running full of ice. Measurement approximate.

Mean daily gage height, in feet, of Susquehanna River at Harrisburg, Pa., for 1904.[a]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.16	4.41	9.41	6.40	7.65	3.65	1.90	1.58	1.43	1.78	2.08	1.79
2	2.16	4.16	11.50	10.15	6.65	3.90	1.73	1.68	1.28	1.68	1.98	1.54
3	4.00	4.00	11.91	13.06	6.40	4.23	1.98	1.93	1.23	1.53	1.88	1.44
4	3.16	4.75	13.50	11.15	5.65	4.23	1.90	1.93	1.23	1.78	1.78	1.24
5	3.16	3.41	22.00	9.40	4.90	3.98	1.65	1.88	1.18	1.93	1.68	1.29
6	2.91	4.41	19.41	7.73	4.06	4.90	1.73	1.78	1.13	1.73	1.64	.94
7	2.91	3.75	16.33	6.78	3.98	5.23	1.73	2.08	1.08	1.58	1.60	1.29
8	2.83	3.83	21.16	6.15	3.81	4.73	2.23	2.03	.98	1.48	1.54	1.09
9	2.83	5.50	15.91	6.06	3.48	3.98	2.56	1.78	.98	1.38	1.54	1.24
10	[b]2.83	9.08	15.00	6.40	3.40	3.56	2.56	1.68	1.18	1.23	1.49	1.19
11	3.00	9.33	12.00	8.48	3.15	4.31	4.48	1.88	1.18	1.18	1.59	.84
12	3.58	8.41	9.16	9.15	2.98	5.40	5.06	1.63	1.18	1.23	1.54	.94
13	3.83	9.91	7.91	7.98	2.90	4.65	4.40	1.58	1.13	1.23	1.59	1.69
14	4.91	13.50	6.58	7.15	2.56	3.90	3.73	1.48	1.08	1.23	1.69	1.44
15	4.66	12.50	6.08	6.31	2.81	3.23	3.23	1.33	1.38	1.38	1.64	1.49
16	4.50	11.58	5.58	5.25	3.15	2.90	2.90	1.33	1.58	2.93	1.59	1.39
17	5.00	10.16	5.25	5.15	3.40	2.65	2.56	1.28	1.98	2.73	1.54	1.30
18	5.00	9.91	4.83	5.06	3.65	2.81	2.28	1.23	2.18	2.38	1.49	1.50
19	4.25	9.16	4.66	4.56	3.98	2.81	2.08	1.13	1.78	2.13	1.59	1.50
20	4.08	9.16	4.66	4.48	4.98	2.56	1.98	1.18	1.78	1.88	1.59	1.50
21	4.16	8.66	5.00	3.90	6.06	2.56	2.03	1.28	1.63	1.73	1.49	1.40
22	4.66	9.16	5.58	3.31	6.56	2.65	1.88	1.18	1.43	1.88	1.54	1.40
23	5.50	10.16	6.66	3.73	5.31	2.56	1.93	1.28	1.33	2.93	1.59	1.50
24	[c]15.50	10.16	7.08	3.56	4.56	2.56	2.98	1.28	1.18	3.76	1.69	1.60
25	11.50	10.75	10.41	3.40	4.23	2.73	2.13	1.28	1.18	4.06	1.69	1.60
26	10.16	10.41	11.00	3.48	3.81	2.48	1.83	1.68	1.08	3.58	1.79	1.60
27	7.66	10.58	15.25	3.48	3.98	2.31	1.73	2.33	1.03	3.03	1.89	1.80
28	6.83	9.50	13.83	3.73	3.90	2.06	1.68	2.08	1.13	2.68	1.84	1.90
29	5.83	9.08	12.50	4.90	3.65	1.98	1.78	1.83	1.63	2.53	1.74	2.10
30	4.75	.....	10.16	6.98	3.31	1.81	1.68	1.63	1.73	2.48	1.84	9.40
31	4.50	.....	8.41	.....	3.40	.....	1.63	1.53	.....	2.28	.....	8.40

[a] From January 1 to July 17, inclusive, gage readings were taken at the pump house. From July 18 to the end of the year the readings were taken at the Walnut Street Bridge. Beginning with April 1 the readings at the pump house were too high by 0.6 foot, owing to the fact that a cofferdam was built just below the intake. This correction has been applied; therefore the gage readings for the complete year are referred to the low-water datum of 1903.

[b] River frozen over at 5 a. m.

[c] Several ice gorges existed both above and below Harrisburg from January 24 to March 13. These caused the backing up of the water, thus increasing the gage height.

Rating table for Susquehanna River at Harrisburg, Pa., from 1891 to 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
−0.05	2,330	2.4	16,950	5.8	65,000	12.0	174,500
+0.0	2,440	2.5	17,960	6.0	68,400	12.5	183,600
.1	2,710	2.6	19,010	6.2	71,900	13.0	193,000
.2	3,000	2.7	20,100	6.4	75,500	13.5	202,500
.3	3,330	2.8	21,210	6.6	79,200	14.0	212,000
.4	3,680	2.9	22,340	6.8	82,900	14.5	221,300
.5	4,070	3.0	23,480	7.0	86,500	15.0	231,000
.6	4,500	3.1	24,620	7.2	90,000	15.5	242,300
.7	4.980	3.2	25,760	7.4	93,400	16.0	254,500
.8	5,500	3.3	26,910	7.6	96,700	16.5	267.400
.9	6,020	3.4	28,130	7.8	100,100	17.0	280.400
1.0	6,550	3.5	29,430	8.0	103,500	17.5	293,600
1.1	7,090	3.6	30,800	8.2	106,900	18.0	306,700
1.2	7,650	3.7	32,200	8.4	110,300	19.0	334,500
1.3	8,240	3.8	33,600	8.6	113,800	20.0	363,100
1.4	8,850	3.9	35,000	8.8	117,300	21.0	392,600
1.5	9,520	4.0	36,400	9.0	120,800	22.0	423,100
1.6	10,200	4.2	39,200	9.2	124,300	23.0	454,600
1.7	10,930	4.4	42,200	9.4	127,800	24.0	487,000
1.8	11,700	4.6	45,400	9.6	131,400	25.0	520,200
1.9	12,500	4.8	48,600	9.8	134,900	26.0	554,400
2.0	13,300	5.0	51,900	10.0	138,400	27.0	589,400
2.1	14,160	5.2	55,100	10.5	147,200		
2.2	15,050	5.4	58,400	11.0	156,300		
2.3	15,980	5.6	61,700	11.5	165,300		

Mean daily discharge, in second-feet, of Susquehanna River at Harrisburg, Pa., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1.....	(a)	(a)	(a)	75,500	97,600	31,500	12,500	10,060	9,048	11,540	13,980	11,630
2.....	(a)	(a)	(a)	141,000	80,100	35,000	11,160	10,780	8,120	10,780	13,140	9,792
3.....	(a)	(a)	(a)	194,200	75,500	39,600	13,140	12,740	7,824	9,724	12,340	9,114
4.....	(a)	(a)	(a)	159,000	62,500	39,600	12,500	12,740	7,824	11,540	11,540	7,892
5.....	(a)	(a)	(a)	127,800	50,200	36,120	10,560	12,340	7,538	12,740	10,780	8,180
6.....	(a)	(a)	(a)	98,900	37,200	50,200	11,160	11,540	7,258	11,160	10,490	6,228
7.....	(a)	(a)	(a)	81,600	36,120	55,600	11,160	13,980	6,982	10,060	10,200	8,180
8.....	(a)	(a)	(a)	71,000	33,740	47,500	15,330	13,550	6,442	9,384	9,792	7,036
9.....	(a)	(a)	(a)	69,400	29,170	36,120	18,590	11,540	6,442	8,726	9,792	7,892
10.....	(a)	(a)	(a)	75,500	28,130	30,250	18,590	10,780	7,538	7,824	9,432	7,594
11.....	(a)	(a)	(a)	111,600	25,190	40,800	43,480	12,340	7,538	7,538	10,130	5,708
12.....	(a)	(a)	(a)	123,400	23,250	58,400	52,900	10,420	7,538	7,824	9,792	6,228

a The ice gorge during January, February, and March make it impossible to estimate daily flow.

Mean daily discharge, in second-feet, of Susquehanna River at Harrisburg, Pa., for 1904—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
13	(a)	(a)	(a)	103,200	22,340	46,200	42,200	10,060	7,258	7,824	10,130	10,860
14	(a)	(a)	(a)	89,200	18,590	35,000	32,620	9,384	6,982	7,824	10,860	9,114
15	(a)	(a)	(a)	73,900	21,320	26,100	26,100	8,420	8,726	8,726	10,490	9,452
16	(a)	(a)	(a)	55,900	25,190	22,340	22,340	8,420	10,060	22,680	10,130	8,788
17	(a)	(a)	(a)	54,300	28,130	19,550	18,590	8,120	13,140	20,440	9,792	8,240
18	(a)	(a)	(a)	52,900	31,500	21,320	15,790	7,824	14,870	16,750	9,452	9,520
19	(a)	(a)	(a)	44,800	36,120	21,320	13,980	7,258	11,540	14,420	10,130	9,520
20	(a)	(a)	(a)	43,500	51,540	18,590	13,140	7,538	11,540	12,340	10,130	9,520
21	(a)	(a)	(a)	35,000	69,400	18,590	13,550	8,120	10,420	11,160	9,452	8,850
22	(a)	(a)	(a)	27,030	78,400	19,550	12,340	7,538	9,048	12,340	9,792	8,850
23	(a)	(a)	(a)	32,620	56,900	18,590	12,740	8,120	8,420	22,680	10,130	9,520
24	(a)	(a)	(a)	30,250	44,800	18,590	23,250	8,120	7,538	33,040	10,860	10,200
25	(a)	(a)	(a)	23,130	39,600	20,440	14,420	8,120	7,538	37,240	10,860	10,200
26	(a)	(a)	(a)	29,170	33,740	17,760	11,940	10,780	6,982	30,520	11,620	10,200
27	(a)	(a)	(a)	29,170	36,120	16,080	11,160	16,270	6,712	28,820	12,420	11,700
28	(a)	(a)	(a)	32,620	35,000	13,820	10,780	13,980	7,258	19,880	12,020	12,500
29	(a)	(a)	(a)	50,200	31,500	13,140	11,540	11,940	10,420	18,270	11,230	14,160
30	(a)	(a)	(a)	86,100	27,030	11,780	10,780	10,420	11,160	17,760	12,020	b51,120
31	(a)	(a)	(a)	.....	28,130	.....	10,420	9,724	.....	15,790	.....	b44,120

a The ice gorge during January, February, and March make it impossible to estimate daily flow.
b Discharge for December 30 and 31 reduced to 40 per cent on account of ice gorge.

Estimated monthly discharge of Susquehanna River at Harrisburg, Pa., for 1904.

[Drainage area, 24,030 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January a	.....	.....	30,410	1.27	1.47
February a	.....	.....	38,590	1.61	1.74
March a	.....	.....	102,000	4.24	4.89
April	194,200	27,030	74,230	3.09	3.45
May	97,600	18,590	41,740	1.74	2.01
June	58,400	11,780	29,320	1.22	1.36
July	52,900	10,420	18,020	.750	.865
August	16,270	7,258	10,420	.434	.500
September	14,870	6,442	8,657	.360	.402
October	37,240	7,538	15,240	.634	.731
November	13,980	9,452	10,760	.448	.500
December	51,120	5,708	8,448	.352	.405
The year	.....	.....	32,320	1.350	18.320

a Owing to an ice gorge below Harrisburg the monthly mean for January, February, and March has been estimated by taking 89 per cent of means for McCall Ferry. Practically open conditions exist at the latter station.

SUSQUEHANNA RIVER AT M'CALL FERRY, PA.

This station is located at a narrow and rocky part of the Susquehanna River about 20 miles above its mouth and 1 mile above the village of McCall Ferry. It was established on May 17, 1902, by Boyd Ehle while investigating a power development there. For a considerable distance along this portion of the river the bank on the York County shore is the retaining wall of an abandoned canal which can be overtopped only in the greatest floods. The Lancaster shore, on the opposite side, is made up of almost equally vertical rock, and the railroad which skirts it has never yet been flooded at this point.

The gaging section first selected for this station is located at Duncan Run, where two islands, Hartman and Streepers, divide the river into three channels, ranging in width from 100 to 500 feet. At ordinary low water, however, two of these are dry, thus confining the discharge to the main or westernmost channel. The river bed at this section is of mica schistose rock, with some projecting bowlders and large irregularities. The flow, however, is comparatively free from the boils so common in a river of this character.

The discharge measurements at this section are made from a boat held in place by a rope stretched between the towpath and Streepers Island, the gaging points, 10 feet apart, being indicated by a tagged wire, which is also used in keeping the boat parallel to the current of the stream.

In order to provide for measuring the large floods which occur in the winter and spring months, a cable station was established by Mr. Ehle in the fall of 1902 about 1,000 feet downstream from the Duncan Run section. The banks of the river and the conditions of the river bed are very similar to those at the upper section, the only difference being that the bed is somewhat more irregular. During the low-water period of the fall of 1902 a careful survey was made of the section at the cable station and a contour map with 1-foot intervals was prepared from which the effective areas could be accurately determined, thus eliminating the error in discharge due to possible inaccuracies in the soundings at the time of the measurements. The width of the stream at this point is about 1,300 feet and the maximum depth during a gaging was 46 feet.

The car cable, a three-quarters inch 37-wire strand with a span of 1,450 feet, is anchored to 3-inch eyebolts set in cement in the solid rock on either side of the river. A 2-inch turn-buckle is provided at the York County end to regulate its height above the water. A high cliff on one shore and a large red oak on the other give the cable a 10-foot clearance over the highest floods on record. The car that runs on the cable accommodates two people and is propelled by a sheave provided with a crank. Eighty feet upstream from the main cable is

suspended a five-eighths inch secondary cable, along which runs a trolley carrying a guy rope to hold the meter against the current. Measuring points for this section are 50 feet apart, and are indicated by red and white bands painted on the main cable, the intermediate distances being readily estimated by counting the revolutions of the sheaves.

The measurements at both of the above stations are referred to two permanent gages, designated Nos. 2 and 5. These are painted on the rock, and give elevations directly above sea level. Gage No. 2 is located at a point about three-fourths of a mile below the village of McCall Ferry, in the tailrace of the proposed power house, and has been read daily since June, 1902. The records in the following tables have been referred to this gage. Gage No. 5 is placed about 2 miles below McCall Ferry, at the foot of Cullys Falls, so located in order to be entirely out of the influence of the proposed dam. One of the purposes of such extensive preparations as have been made at this point is to obtain data for determining the coefficient of discharge over ogee-faced weirs under high heads, and it is for use in these investigations that gage No. 5 was established.

The methods used in carrying on the work at the McCall Ferry station are practically the same as those employed by the hydrographers of the United States Geological Survey. Every effort has been made to eliminate any source of error, and vertical velocity-curve determinations were made wherever possible. At Duncan Run, in order to make these measurements, an 80-pound weight, with pulley and rope attached, was dropped to the bottom, so that the meter could be pulled down without being washed too far from the section. When the surface velocity, or 0.6 method, was used, the results were reduced by coefficients determined from these vertical velocity-curves. At the cable station the secondary cable, with the aid of the guy rope, made it possible to get vertical velocity-curve measurements at much greater velocities and depths. A No. 12 telegraph wire was found to be more satisfactory at such times for holding the meter than the insulated cable ordinarily used, as it offered less resistance to the current, would allow the meter to sink deeper, and, being less bowed by the water, would show more accurately its depth below the surface. In this way vertical velocity-curves were obtained to depths of 20 feet and in currents of 10 feet per second.

During the highest stages, when the velocity sometimes reaches 17 feet per second, readings could be taken only at the surface. These results were, however, reduced by coefficients determined from the vertical velocity-curve for each measuring point.

All records and estimates for this station for years prior to 1905 have been published in Water-Supply Paper No. 109.

Discharge measurements of Susquehanna River at McCall Ferry, Pa., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.[a]	Discharge.
		Sq. ft.	*Ft. per sec.*	*Feet.*	*Second-ft.*
March 8[a]	R. H. Anderson	54,500	[c]11.6	146.6	631,000
May 11[a]	do	7,035	[c]4.7	119.00	34,400
September 29[b]	W. G. Steward	3,717	2.16	114.75	7,940

[a] At cable section. [b] At Duncan Run section. [c] Reduced surface velocities.

Mean daily gage height, in feet, of Susquehanna River at McCall Ferry, Pa., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	116.6	120.0	120.0	123.9	125.2	119.4	116.8	115.8	115.5	116.2	117.1	116.0
2	116.3	119.0	121.0	129.2	124.4	119.3	116.5	115.7	115.3	116.1	116.9	115.9
3	115.9	118.5	122.0	132.6	123.3	119.9	116.3	116.0	115.1	116.0	116.8	115.8
4	[a]115.8	117.9	122.9	130.0	122.5	120.4	116.0	116.6	115.5	115.8	116.5	115.5
5	116.0	117.3	128.0	127.0	121.5	120.2	116.0	116.6	115.3	115.9	116.3	115.3
6	116.5	117.0	128.0	125.0	120.9	120.8	116.0	116.4	115.1	115.5	116.2	115.3
7	116.9	118.5	126.4	123.9	120.0	122.3	116.2	116.6	115.0	115.8	115.9	115.2
8	115.8	119.4	[b]146.6	123.1	119.8	121.4	116.5	116.7	114.9	115.7	115.7	115.0
9	115.5	121.5	130.2	123.2	119.5	120.1	117.0	116.7	114.8	115.5	115.5	114.8
10	115.5	125.0	130.4	123.4	119.3	119.9	117.5	117.0	114.7	115.4	115.7	114.7
11	116.0	125.7	130.9	124.6	119.0	119.6	119.9	117.5	114.7	115.3	115.5	114.5
12	116.8	124.3	126.6	127.3	118.6	121.7	121.0	117.0	114.8	115.4	115.5	114.4
13	117.1	122.7	124.9	125.9	118.3	121.0	121.1	116.4	115.0	115.4	115.6	114.2
14	117.3	121.9	123.6	124.4	118.3	119.9	119.9	116.0	115.3	115.4	115.9	114.2
15	117.3	121.0	122.3	123.6	118.2	119.3	119.0	115.7	115.8	115.3	116.0	114.4
16	117.4	120.4	121.5	122.6	119.0	118.5	118.5	115.5	116.1	115.4	116.0	115.3
17	117.0	119.5	121.1	121.9	119.5	118.3	118.7	115.3	116.4	118.2	115.9	114.6
18	116.6	118.6	120.7	121.6	119.7	118.0	117.4	115.2	117.0	118.0	115.8	114.6
19	116.4	118.0	120.9	121.0	120.3	118.0	117.0	115.2	116.8	117.5	115.7	114.6
20	116.0	117.8	121.0	120.6	121.3	117.9	116.8	115.3	116.5	116.8	115.7	114.5
21	116.0	118.0	121.6	120.2	122.7	117.8	116.6	115.7	116.3	117.0	115.7	114.6
22	117.4	120.0	122.6	120.1	123.8	117.2	116.5	115.6	116.0	117.3	115.6	114.5
23	122.3	120.9	123.0	119.9	122.8	118.0	116.4	115.5	115.8	117.5	115.5	114.5
24	[c]120.7	120.1	123.9	119.5	121.0	117.9	116.4	115.4	115.6	118.7	115.7	114.8
25	129.3	120.7	128.3	119.3	120.6	118.0	117.8	115.3	115.2	119.7	115.7	115.0
26	126.8	120.7	130.0	119.2	119.9	117.8	117.4	115.4	114.9	120.0	115.8	114.9
27	124.0	120.3	131.6	119.3	120.2	117.3	116.5	115.7	114.8	119.3	116.0	115.0
28	123.0	119.8	132.9	119.7	119.9	116.9	116.3	116.9	114.6	118.5	116.3	115.1
29	122.3	119.0	130.7	121.0	119.6	116.8	116.0	116.6	114.8	117.9	115.7	115.5
30	121.4	.....	128.9	122.1	119.0	116.7	116.0	116.1	115.8	117.8	116.1	116.2
31	120.5	.....	125.3	.....	119.6	.....	115.9	115.8	.....	117.5	.....	123.0

[a] Entire river covered with 14- to 18-inch ice.
[b] Ice moved at 2 p. m.
[c] Ice broke and went out of deeps at 5.30 p. m.; 133.8 maximum reading during night, 24th and 25th

Rating table for Susquehanna River at McCall Ferry, Pa., for 1902 to 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
114.0	5,160	116.4	15,610	120.6	44,200	126.0	112,900
114.1	5,500	116.5	16,150	120.8	46,100	126.5	119,900
114.2	5,840	116.6	16,690	121.0	48,000	127.0	127,000
114.3	6,200	116.7	17,240	121.2	50,000	127.5	134,100
114.4	6,560	116.8	17,800	121.4	52,100	128.0	141,100
114.5	6,930	116.9	18,360	121.6	54,300	128.5	148,300
114.6	7,310	117.0	18,930	121.8	56,600	129.0	155,300
114.7	7,700	117.2	20,120	122.0	59,000	129.5	163,400
114.8	8,100	117.4	21,320	122.2	61,500	130.0	172,500
114.9	8,500	117.6	22,560	122.4	64,000	130.5	182,800
115.0	8,920	117.8	23,820	122.6	66,500	131.0	194,100
115.1	9,340	118.0	25,110	122.8	69,000	131.5	205,800
115.2	9,770	118.2	26,430	123.0	71,500	132.0	217,300
115.3	10,210	118.4	27,780	123.2	74,000	132.5	228,600
115.4	10,660	118.6	29,140	123.4	76,400	133.0	240,000
115.5	11,120	118.8	30,500	123.6	78,900	133.5	251,200
115.6	11,580	119.0	31,900	123.8	81,500	134.0	262,000
115.7	12,060	119.2	33,300	124.0	84,200	134.5	273,600
115.8	12,540	119.4	34,700	124.2	87,000	135.0	285,300
115.9	13,040	119.6	36,100	124.4	89,900	135.5	297,200
116.0	13,540	119.8	37,500	124.6	92,800	136.0	309,300
116.1	14,040	120.0	39,100	124.8	95,700		
116.2	14,560	120.2	40,700	125.0	98,600		
116.3	15,080	120.4	42,400	125.5	105,900		

Mean daily discharge, in second-feet, of Susquehanna River at McCall Ferry, Pa., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	16,690	39,100	39,100	82,800	101,500	34,700	17,800	12,540	11,120	14,560	19,520	13,540
2	15,080	31,900	48,000	158,400	89,900	34,000	16,150	12,060	10,210	14,040	18,360	13,040
3	13,040	28,460	59,000	230,900	75,200	38,300	15,080	13,540	9,340	13,540	17,800	12,540
4	12,540	24,460	70,200	172,500	65,300	42,400	13,540	16,690	11,120	12,540	16,150	11,120
5	13,540	20,720	141,100	127,000	53,200	40,700	13,540	16,690	10,210	13,040	15,080	10,210
6	16,150	18,930	141,100	98,600	47,050	46,100	13,540	15,610	9,340	11,120	14,560	10,210
7	18,360	28,460	118,500	82,800	39,100	62,800	14,560	16,690	8,920	12,540	13,040	9,340
8	12,540	34,700	[a]300,000	72,700	37,500	52,100	16,150	17,240	8,500	12,060	12,060	8,920
9	11,120	53,200	176,500	74,000	35,400	39,900	18,930	17,240	8,100	11,120	11,120	8,100
10	11,120	98,600	180,700	76,400	34,000	38,300	21,940	18,930	7,700	10,660	12,060	7,700
11	13,540	108,700	192,000	92,800	31,900	36,100	38,300	21,940	7,700	10,210	11,120	6,930
12	17,800	88,500	121,300	131,300	29,140	55,400	48,000	18,930	8,100	10,660	11,120	6,560
13	19,520	67,700	97,100	111,500	27,100	48,000	49,000	15,610	8,920	10,660	11,580	5,840
14	20,720	57,800	78,900	89,900	27,100	38,300	38,300	13,540	10,210	10,660	13,040	5,840

[a] Maximum discharge, 631,000 mean daily discharge estimated.

Mean daily discharge, in second-feet, of Susquehanna River at McCall Ferry, Pa., for 1904—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
15	20,720	48,000	62,800	78,900	26,430	34,000	31,900	12,060	12,540	10,210	13,540	6,560
16	21,320	42,400	53,200	66,500	31,900	28,460	28,460	11,120	14,040	10,660	13,540	10,210
17	18,930	35,400	49,000	57,800	35,400	27,100	29,820	10,210	15,610	26,430	13,040	7,310
18	16,690	29,140	45,100	54,300	36,800	25,110	21,320	9,770	18,930	25,100	12,540	7,310
19	15,610	25,110	47,050	48,000	41,550	25,110	18,930	9,770	17,800	21,940	12,060	7,310
20	13,540	23,820	48,000	44,200	51,100	24,460	17,800	10,210	16,150	17,800	12,060	6,930
21	13,540	25,110	54,300	40,700	67,700	23,820	16,690	12,060	15,080	18,930	12,060	7,310
22	21,320	39,100	66,500	39,900	81,500	20,120	16,150	11,580	13,540	20,720	11,580	6,930
23	62,800	47,050	71,500	38,300	69,000	25,110	15,610	11,120	12,540	21,940	11,120	6,930
24	45,100	39,900	82,800	35,400	48,000	24,460	15,610	10,660	11,580	29,820	12,060	8,100
25	160,000	45,100	145,500	34,000	44,200	25,110	23,820	10,210	9,770	36,800	12,060	8,920
26	124,100	45,100	172,500	33,300	38,300	23,820	21,320	10,660	8,500	39,100	12,540	8,500
27	84,200	41,550	208,100	34,000	40,700	20,720	16,150	12,060	8,100	34,000	13,540	8,920
28	71,500	37,500	237,700	36,800	38,300	18,360	15,080	18,360	7,310	28,460	15,080	9,340
29	62,800	31,900	187,200	48,000	36,100	17,800	13,540	16,690	8,100	24,460	12,060	11,120
30	52,100	.....	153,900	60,200	31,900	17,240	13,540	14,040	12,540	23,820	14,040	14,560
31	43,300	.....	103,000	.....	36,100	.....	13,040	12,540	.....	21,940	.....	71,500

Estimated monthly discharge of Susquehanna River at McCall Ferry, Pa., for 1904.

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	160,000	11,120	34,170	1.28	1.48
February	108,700	18,930	43,360	1.62	1.75
March	300,000	39,100	114,600	4.28	4.93
April	230,900	33,300	78,400	2.93	3.27
May	101,500	26,430	46,720	1.75	2.02
June	62,800	17,240	34,580	1.29	1.44
July	49,000	13,040	21,410	.800	.922
August	21,940	9,770	13,880	.519	.598
September	18,930	7,310	11,050	.413	.461
October	39,100	10,210	18,700	.698	.805
November	19,520	11,120	13,320	.498	.556
December	71,500	5,840	10,890	.407	.469
The year	300,000	5,840	36,760	1.37	18.70

CHENANGO RIVER AT BINGHAMTON, N. Y.

This station was established July 31, 1901. A standard chain gage is attached to the hand rail on the upstream side of the first span from the right bank of Court Street Bridge in Binghamton. The bench mark is a circular chisel draft on the upstream corner of the bridge seat on the left abutment. Its elevation is 34.02 feet above gage datum. The bridge to which the gage is attached stands squarely across the stream at a point where there is a good bed of gravel and small cobblestones and a smooth, uniform current. The channel is obstructed by three masonry piers supporting the four spans of the bridge, 79 feet clear width each, the bridge having a total length of 337 feet between abutments. A small rift between the station and the confluence of Chenango River with the Susquehanna, about 2,500 feet below, cuts off backwater at ordinary stages of the rivers. For periods during freshets or at times when there is an abnormal rise on one or both streams, either record may be affected by backwater and a too great discharge indicated. For freshets of considerable duration the effect of backwater on the stage of the two streams may become inconsiderable.

In estimating run-off of Chenango River the area directly tributary to storage reservoirs, from which diversion is made to supply Erie Canal, has been deducted from the total natural drainage area. The diversion area of six reservoirs at the head of Chenango River, whose outflow is turned into Erie Canal through Oriskany Creek, is 30 square miles. The diversion area of De Ruyter reservoir, at the head of Tioughnioga River, whose outflow is turned into Erie Canal through Limestone Creek, is 18 square miles. These two areas have been sub tracted from the natural drainage area of 1,580 square miles, giving an effective area of 1,532 square miles. This estimate is approximate, as no allowance for direct inflow to feeder channels from additional areas, nor for waste into the original stream, has been made. The gross area from which more or less run-off is diverted is about 105 square miles. Gage readings on Chenango River, as well as those on Susquehanna River at Binghamton, are taken by E. F. Weeks. All records and estimates for this station for years prior to 1905 have been revised and republished in Water-Supply Paper No. 109.

The observations at this station during 1904 have been made under the direction of R. E. Horton, district hydrographer.

Discharge measurements of Chenango River at Binghamton, N. Y., in 1904.

Date.	Hydrographer.	Area.	Mean velocity.	Gage height.	Discharge.
		Sq. ft.	*Ft. per sec.*	*Feet.*	*Second-feet.*
March 8	C. C. Covert	3,702	3.45	[a]14.90	9,104
April 8	R. E. Horton	2,459	5.42	10.86	11,632
July 12	C. C. Covert	595	.87	5.42	516
September 10	do	417	1.15	5.55	539
November 22	H. R. Beebe	1,022	2.45	6.86	2,505

[a] Backwater, caused by ice jam.

Mean daily gage height, in feet, of Chenango River at Binghamton, N. Y., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	6.42	7.32	7.60	11.30	8.72	7.14	5.59	6.10	5.70	7.69	6.22	6.15
2	6.55	7.20	7.40	12.90	8.19	6.79	5.73	7.08	5.72	6.85	6.20	5.96
3	[b]6.42	7.18	7.88	[a]11.70	7.79	6.56	5.63	7.35	5.70	6.41	6.12	5.80
4	6.45	7.20	10.38	10.50	7.42	6.42	5.61	6.88	5.72	6.21	6.07	5.75
5	6.68	7.05	11.92	9.45	7.19	6.64	5.51	6.32	5.65	6.11	6.04	5.65
6	[c]6.82	6.75	11.08	10.08	6.99	6.59	5.49	6.72	5.65	6.01	6.17	5.72
7	6.68	8.12	[c]10.95	10.30	6.82	6.34	5.51	6.65	5.60	6.01	6.23	5.80
8	6.60	13.92	14.78	10.88	6.67	6.25	5.58	6.28	5.52	5.96	6.16	5.75
9	6.58	15.30	16.90	11.01	6.55	6.88	5.48	6.10	5.50	5.88	6.11	5.62
10	6.48	14.28	15.65	12.97	6.44	7.98	5.40	6.02	5.50	5.80	6.11	5.56
11	6.38	12.05	13.70	12.42	6.34	6.93	5.30	5.98	5.40	6.05	6.06	5.58
12	6.30	10.60	11.40	10.84	6.26	6.48	5.50	5.92	5.31	7.60	6.06	5.62
13	6.25	9.50	10.30	9.91	6.18	6.25	5.55	5.85	5.31	8.95	6.01	5.70
14	6.20	8.70	9.52	9.29	6.14	6.15	5.35	5.75	5.34	7.85	6.02	5.55
15	6.15	8.20	8.75	8.74	6.26	6.08	5.40	5.72	6.09	7.03	5.95	5.65
16	6.15	[e]9.38	8.20	8.49	7.86	6.53	5.60	5.65	5.91	6.40	6.08	5.65
17	6.12	10.18	7.65	8.39	7.36	6.11	5.65	5.70	5.67	6.42	6.10	5.65
18	[b]6.15	10.05	7.42	8.39	6.84	5.94	6.68	5.62	5.54	6.26	5.95	5.65
19	6.30	9.52	7.22	8.40	6.64	5.84	6.55	5.55	5.40	6.16	5.92	5.60
20	6.45	8.98	7.48	8.23	7.30	5.84	6.08	5.78	5.36	6.12	5.90	5.60
21	6.30	8.62	7.88	7.98	7.10	5.84	5.88	6.82	5.46	5.79	6.08	5.60
22	6.30	8.35	7.78	7.98	6.70	5.82	5.82	6.50	5.68	10.79	6.80	5.60
23	[d]10.36	8.62	11.30	8.00	6.47	5.72	5.65	8.25	5.66	9.76	6.68	5.65
24	11.18	9.35	[f]15.15	7.93	6.73	5.60	6.10	7.55	5.56	8.15	6.50	5.92
25	11.60	9.38	15.90	8.13	6.47	5.54	6.02	6.65	6.70	7.38	6.38	6.50
26	10.20	8.70	19.82	8.43	6.40	5.54	5.92	6.32	6.42	7.41	6.32	6.25
27	9.35	8.25	19.90	8.13	6.50	5.47	6.20	6.20	6.29	7.23	6.18	6.72
28	8.65	7.95	16.15	10.13	6.50	5.46	6.22	[a]6.05	6.15	6.92	5.98	12.75
29	8.10	7.88	12.08	10.19	6.40	5.46	6.65	5.90	5.95	6.68	5.80	13.25
30	7.88	.....	10.62	9.39	6.26	5.49	6.90	5.80	6.92	6.53	6.20	10.15
31	7.60	.....	10.58	.....	6.76	.....	6.32	5.72	.....	6.32	.....	5.25

[a] Interpolated.
[b] Anchor ice.
[c] River partly frozen over.
[d] Current very sluggish.
[e] Backwater.
[f] Ice went out.

Rating table for Chenango River at Binghamton, N. Y., for 1901 to 1904, inclusive.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
5.0	160	7.4	3,200	10.6	8,590	15.4	18,240
5.1	256	7.5	3,350	10.8	8,970	15.6	18,660
5.2	352	7.6	3,500	11.0	9,350	15.8	19,080
5.3	450	7.7	3,650	11.2	9,730	16.0	19,500
5.4	550	7.8	3,800	11.4	10,110	16.2	19,940
5.5	650	7.9	3,950	11.6	10,490	16.4	20,380
5.6	760	8.0	4,100	11.8	10,870	16.6	20,820
5.7	875	8.1	4,250	12.0	11,250	16.8	21,260
5.8	995	8.2	4,400	12.2	11,650	17.0	21,700
5.9	1,115	8.3	4,550	12.4	12,050	17.2	22,140
6.0	1,235	8.4	4,700	12.6	12,450	17.4	22,580
6.1	1,365	8.5	4,850	12.8	12,850	17.6	23,030
6.2	1,495	8.6	5,020	13.0	13,250	17.8	23,490
6.3	1,625	8.7	5,190	13.2	13,650	18.0	23,950
6.4	1,755	8.8	5,360	13.4	14,050	18.2	24,410
6.5	1,885	8.9	5,530	13.6	14,460	18.4	24,870
6.6	2,025	9.0	5,700	13.8	14,880	18.6	25,340
6.7	2,165	9.2	6,060	14.0	15,300	18.8	25,820
6.8	2,305	9.4	6,420	14.2	15,720	19.0	26,300
6.9	2,450	9.6	6,780	14.4	16,140	19.2	26,780
7.0	2,600	9.8	7,140	14.6	16,560	19.4	27,260
7.1	2,750	10.0	7,500	14.8	16,980	19.6	27,760
7.2	2,900	10.2	7,860	15.0	17,400	19.8	28,280
7.3	3,050	10.4	8,220	15.2	17,820		

Remarks: Tangent at 19.5 feet. Difference above this point 260 per tenth.

Mean daily discharge, in second-feet, of Chenango River at Binghamton, N. Y., for 1904.

Day.	Jan.	Feb.	Mar.	Apr	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1,781	3,050	3,500	9,920	5,190	2,825	749	1,365	875	3,650	1,521	1,430
2	1,955	2,900	3,200	13,050	4,400	2,291	911	2,750	899	2,375	1,495	1,175
3	1,781	2,900	3,950	10,680	3,800	1,969	793	3,125	875	1,768	1,391	995
4	1,820	2,900	5,750	8,400	3,200	1,781	771	2,420	899	1,508	1,326	935
5	2,137	2,675	9,000	6,510	2,900	2,081	661	1,651	815	1,378	1,287	818
6	2,333	2,235	8,500	7,680	2,585	2,011	640	2,193	815	1,248	1,456	899
7	2,137	4,250	8,300	8,040	2,333	1,677	661	2,095	760	1,248	1,534	995
8	2,025	15,090	8,985	9,160	2,123	1,560	738	1,599	672	1,187	1,443	935
9	1,997	18,030	11,400	9,350	1,955	2,420	630	1,365	650	1,091	1,378	783
10	1,859	15,930	10,700	13,150	1,807	4,100	550	1,261	650	995	1,378	705
11	1,729	11,350	8,950	12,050	1,677	2,495	450	1,211	550	1,300	1,313	738
12	1,625	8,590	6,670	9,065	1,573	1,859	650	1,139	460	3,500	1,313	783
13	1,560	6,600	5,700	7,320	1,469	1,560	705	1,055	460	5,615	1,248	875

Mean daily discharge, in second-feet, of Chenango River at Binghamton, N. Y., for 1904— Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
14	1,495	5,190	4,950	6,240	1,417	1,430	500	935	490	3,875	1,261	705
15	1,430	4,400	4,170	5,275	1,573	1,339	550	899	1,352	2,675	1,175	818
16	1,430	6,420	3,600	4,850	3,125	1,927	760	815	1,127	1,755	1,339	818
17	1,391	7,860	3,020	4,700	3,125	1,378	815	875	839	1,781	1,365	818
18	1,430	7,590	2,800	4,700	2,361	1,163	2,137	782	694	1,573	1,175	818
19	1,625	6,600	2,680	4,700	2,081	1,043	1,965	705	550	1,443	1,139	760
20	1,820	5,700	3,015	4,475	3,050	1,043	1,339	971	510	1,391	1,115	760
21	1,625	5,020	3,555	4,100	2,750	1,043	1,091	2,333	610	983	1,339	760
22	1,625	4,625	3,350	4,100	2,165	1,019	1,019	1,885	851	8,970	2,395	760
23	8,180	5,020	9,920	4,100	1,846	899	815	4,475	827	7,050	2,137	818
24	9,730	6,330	17,715	4,025	2,207	760	1,365	3,425	716	4,325	1,885	1,139
25	10,490	6,420	19,290	4,325	1,846	694	1,261	2,095	2,165	3,200	1,729	1,885
26	7,860	5,190	28,280	4,775	1,755	694	1,139	1,651	1,781	3,200	1,651	1,560
27	6,330	4,475	28,540	4,325	1,885	620	1,495	1,495	1,612	2,975	1,469	2,195
28	5,105	4,025	19,830	7,770	1,885	610	1,521	1,300	1,430	2,480	1,211	12,750
29	4,250	3,950	11,450	7,860	1,755	610	2,095	1,115	1,175	2,137	995	13,810
30	3,950	.....	8,590	6,420	1,573	640	2,450	995	2,480	1,927	1,495	7,770
31	3,500	.....	8,590	.....	2,249	.....	1,651	899	.....	1,651	.....	401

The daily discharge during January, February, and March are only approximate, owing to the ice conditions. From March 4 to 22, 1904, the discharge was estimated from the measurement of March 8, which was approximately 50 per cent of normal conditions. This was due to an ice gorge.

Estimated monthly discharge of Chenango River at Binghamton, N. Y., for 1904.

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	10,490	1,391	3,160	2.06	2.37
February	18,030	2,235	6,390	4.17	4.50
March	28,540	2,680	8,966	5.84	6.73
April	13,150	4,025	7,037	4.59	5.12
May	5,190	1,417	2,376	1.55	1.79
June	4,100	610	1,518	.990	1.105
July	2,450	450	1,060	.691	.807
August	4,475	705	1,641	1.07	1.23
September	2,480	460	953	.621	.693
October	8,970	983	2,587	1.69	1.95
November	2,305	995	1,429	.932	1.04
December	13,810	401	1,981	1.29	1.49
The year	28,540	401	3,258	2.12	28.82

CHEMUNG RIVER AT CHEMUNG, N. Y.

Chemung River is formed at Painted Post, N. Y., by the confluence of Tioga and Cohocton rivers. Cohocton River lies entirely in the State of New York. Tioga River receives, just above its mouth, Canisteo River, a large tributary, which also has its drainage basin in New York to the south of the Cohocton. The drainage of Tioga River above the Canisteo is mainly in Pennsylvania. Chemung River flows southeasterly through Corning, Elmira, and Chemung, crosses the State line and flows for a short distance in Pennsylvania, then returns to New York and again crosses to Pennsylvania near Waverly, finally emptying into Susquehanna River near Athens, Bedford County, Pa. The total length of the river is about 40 miles, of which 30 miles lie in New York. It is a sluggish stream, with low banks and a broad valley or flood plain, which is often overflowed. It was formerly paralleled by a canal, which has now been abandoned. The principal water-power development on the river is at Elmira, N. Y.

The topographic features of the drainage basin are, as a rule, bold and broad. The hills rise to a height of several hundred feet on either side, and within a short distance of the stream; the upland plateau is to a large extent wooded, has impervious soil, no lake storage, and few marsh areas. Tributaries are ramifying and uniformly distributed, though not very numerous, and dry gullies or flood channels are common. The concentration of storm waters from the three large streams which unite just above Corning makes possible excessive floods. Dikes have been erected in the cities of Elmira and Corning for protection. One of the highest recorded freshets in the stream occurred June 1, 1889. It was preceded by phenomenal rainfall, aggregating several inches in a few hours during the night of May 31. The discharge at this time has been estimated by F. Collingwood at 67 second-feet per square mile from 2,055 square miles, or 138,000 second-feet.

The gaging station was established September 7, 1903, by R. E. Horton. It is located at the suspension highway bridge, midway between Chemung, N. Y., and Willawana, Pa., near the State line. The bridge has a single span of 395 feet. A standard chain gage is attached to the upstream side of the bridge near the right bank, and is read twice each day by Daniel L. Orcutt. Discharge measurements are made from the downstream side of the bridge. The initial point for soundings is the face of the right abutment on the downstream side. The channel is straight for 700 feet above and 800 feet below the station; the current is good. The right bank is high, cleared, and is not subject to overflow. The left bank is of medium height, wooded, and will overflow at high water. The bed of the stream is composed of gravel, and is clean and permanent. There is but one channel at

all stages. The bench mark is formed by three nails driven into a telephone pole 70 feet to the right of the initial point for soundings and about 30 feet upstream; elevation 29.88 feet above gage datum. The pole is marked with black paint, "U. S. G. S. B. M."

All records and estimates for this station for years prior to 1905 have been revised and republished in Water-Supply Paper No. 109.

The observations at this station during 1904 have been made under the direction of R. E. Horton, district hydrographer.

Discharge measurements of Chemung River at Chemung, N. Y.

Date.	Hydrographer.	Gage height.	Discharge.
1903.		*Feet.*	*Second-feet.*
August 27	C. C. Covert	2.89	809
September 7	R. E. Horton	3.29	1,354
October 2	H. H. Halsey	2.47	611
October 12	C. C. Covert	6.72	8,766
1904.			
March 11	C. C. Covert	5.75	6,170
April 9	R. E. Horton	5.64	5,717
July 15	C. C. Covert	3.05	1,042
September 9	do	1.90	220

Mean daily gage height, in feet, of Chemung River at Chemung, N. Y.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1908.												
1										2.24	2.98	2.90
2										2.40	2.88	2.88
3										2.52	3.88	2.88
4										2.57	2.83	2.88
5										2.74	2.86	2.82
6										3.30	2.90	2.79
7									3.29	3.37	3.08	3.69
8									2.24	4.62	2.98	2.79
9									3.19	9.97	4.93	2.69
10									3.16	7.78	2.90	2.64
11									4.84	8.80	2.68	2.49
12									4.56	6.74	2.86	2.49
13									3.84	6.12	2.80	2.69
14									3.46	4.97	2.73	2.69
15									3.22	4.47	2.68	2.69
16									3.06	4.20	2.76	2.74
17									2.96	3.92	7.06	2.74
18									3.44	7.04	8.13	2.64
19									3.46	6.24	5.88	2.64
20									3.29	4.90	4.88	2.64
21									2.99	4.42	4.26	2.69
22									2.84	4.12	3.98	2.74
23									2.54	3.87	3.88	2.79

Mean daily gage height, in feet, of Chemung River at Chemung, N. Y.—Continued.

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1903.												
24									2.34	4.72	3.83	2.79
25									2.34	3.54	3.78	2.79
26									2.29	3.44	3.38	2.74
27									2.24	3.32	3.23	2.69
28									2.24	3.30	3.10	2.54
29									2.22	3.24	3.10	2.44
30									2.26	3.22	3.10	2.54
31										3.13		2.64
1904.												
1	3.00	[a]3.85	3.57	6.50	7.20	7.05	2.60	2.50	2.00	2.35	2.40	2.05
2	2.95	3.50	3.37	9.00	6.25	5.85	2.88	2.42	2.02	2.42	2.30	2.00
3	2.90	3.45	3.67	7.05	5.45	5.35	2.70	2.98	2.00	2.22	2.22	1.90
4	2.90	3.35	8.57	5.75	5.02	4.85	2.62	2.82	1.95	2.10	2.20	1.90
5	2.90	4.00	5.72	5.38	4.62	7.70	2.60	2.70	2.00	2.15	2.25	1.90
6	2.90	4.20	4.72	5.15	4.40	5.95	2.58	2.60	1.98	2.18	2.20	1.90
7	2.85	5.90	7.69	5.20	4.18	5.10	2.95	2.45	1.92	1.88	2.20	1.85
8	2.90	[a]16.70	[b]15.97	5.25	4.00	4.62	2.85	2.35	1.95	1.95	2.22	1.65
9	3.00	8.70	9.68	5.75	3.80	5.35	2.72	2.20	1.90	1.90	2.12	2.25
10	3.00	6.85	6.48	9.55	3.70	6.15	2.75	2.15	1.90	1.95	2.18	2.10
11	3.00	5.85	5.02	7.40	3.58	4.90	3.90	2.20	1.95	1.95	2.20	2.10
12	3.00	5.40	4.90	6.55	3.40	4.42	3.68	2.18	1.95	2.10	2.20	2.10
13	3.00	4.75	4.50	5.75	3.38	4.00	3.45	2.10	1.95	2.62	2.12	2.00
14	3.00	4.22	4.30	5.15	3.30	3.70	3.45	2.08	1.90	3.65	2.08	2.00
15	3.00	3.95	4.05	4.80	5.15	3.48	3.02	2.00	1.90	3.15	2.05	2.00
16	[c]3.15	3.65	3.88	4.80	6.75	4.05	2.82	2.00	1.90	2.82	2.25	2.00
17	3.20	[d]4.85	3.62	4.80	5.65	3.80	2.70	2.00	1.90	2.70	2.15	1.90
18	3.20	4.55	3.78	5.10	5.00	3.42	2.62	1.95	1.90	2.60	2.20	1.90
19	3.20	[e]4.30	3.92	5.10	9.45	3.22	2.50	1.95	1.90	2.50	2.05	1.95
20	3.20	4.15	5.98	4.85	8.40	3.12	2.40	2.05	1.88	2.45	2.00	2.00
21	3.35	4.00	6.78	4.42	6.60	3.02	2.30	2.05	1.80	2.52	2.00	2.10
22	3.50	[f]4.12	5.20	4.55	5.40	3.10	2.35	2.30	1.75	3.40	2.00	2.05
23	[g]11.35	4.05	[h]10.90	4.60	4.95	3.05	2.25	2.75	1.80	3.40	2.00	2.18
24	[a]9.55	4.32	11.40	4.50	5.35	3.05	2.72	2.88	1.82	3.18	2.02	2.10
25	6.65	4.12	10.25	4.55	5.25	2.88	2.78	2.70	2.00	3.05	2.20	2.10
26	5.30	4.05	[h]13.20	4.82	4.75	2.80	2.55	2.45	2.15	2.85	2.15	2.15
27	4.90	3.90	11.05	4.65	4.82	2.70	2.60	2.30	2.38	2.75	2.00	2.60
28	4.20	3.37	7.28	9.10	5.40	2.65	2.50	2.12	2.35	2.65	1.95	6.40
29	4.22	3.57	5.95	8.50	4.25	2.60	2.70	2.10	2.35	2.60	2.10	5.15
30	4.25	.....	5.60	7.42	4.00	2.60	2.80	2.08	2.35	2.45	1.95	3.90
31	4.05	.....	5.70	.....	5.85	.....	2.62	2.00	.....	2.30	.....	3.80

[a] No ice.
[b] Water over flats highest point 17 feet.
[c] River freezing over below gage.
[d] River frozen over.
[e] Thickness of ice 5 inches.
[f] Thickness of ice 12 inches.
[g] Ice running.
[h] River over the flats.

Rating table for Chemung River at Chemung N. Y., from August 27, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.75	146	4.00	2,255	6.30	7,575	8.60	14,260
1.80	170	4.10	2,420	6.40	7,855	8.70	14,560
1.90	220	4.20	2,590	6.50	8,135	8.80	14,860
2.00	273	4.30	2,765	6.60	8,415	8.90	15,160
2.10	328	4.40	2,950	6.70	8,700	9.00	15,460
2.20	385	4.50	3,140	6.80	8,985	9.10	15,760
2.30	445	4.60	3,340	6.90	9,270	9.20	16,060
2.40	510	4.70	3,550	7.00	9,560	9.30	16,360
2.50	575	4.80	3,765	7.10	9,850	9.40	16,660
2.60	645	4.90	3,990	7.20	10,140	9.50	16,960
2.70	720	5.00	4,220	7.30	10,430	9.60	17,260
2.80	800	5.10	4,455	7.40	10,720	9.70	17,560
2.90	890	5.20	4,695	7.50	11,010	9.80	17,860
3.00	985	5.30	4,940	7.60	11,300	9.90	18,160
3.10	1,085	5.40	5,190	7.70	11,590	10.00	18,460
3.20	1,190	5.50	5,445	7.80	11,880	11.00	21,460
3.30	1,300	5.60	5,700	7.90	12,170	12.00	24,460
3.40	1,415	5.70	5,960	8.00	12,460	13.00	27,460
3.50	1,540	5.80	6,220	8.10	12,760	14.00	30,460
3.60	1,670	5.90	6,485	8.20	13,060	15.00	33,460
3.70	1,805	6.00	6,750	8.30	13,360	16.00	36,460
3.80	1,945	6.10	7,020	8.40	13,660		
3.90	2,095	6.20	7,295	8.50	13,960		

The above table is applicable only for open-channel conditions. It is based upon 8 discharge measurements made during 1903 and 1904. It is fairly well defined between gage heights 1.90 and 3.30 feet. The table has been extended above gage height 6.70 feet. Above gage height 8.00 feet the rating curve is a tangent, the difference being 300 per tenth. The rating table has been applied to the nearest hundredth of a foot to gage height 6.00, to the nearest half-tenth of a foot to gage height 9.00, to the nearest tenth of a foot above gage height 9.00 feet.

Mean daily discharge, in second-feet, of Chemung River at Chemung, N. Y.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1903.												
1										409	966	880
2										510	872	872
3										589	2,065	872
4										624	827	872
5										752	854	818
6										1,300	890	638
7									1,289	1,380	1,065	1,791
8									409	3,382	966	792

Mean daily discharge, in second-feet, of Chemung River at Chemung, N. Y.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1903.												
9									1,180	18,460	4,059	712
10									1,148	11,880	890	675
11									3,855	14,860	872	568
12									3,260	8,840	854	569
13									2,005	7,020	800	712
14									1,490	4,157	748	712
15									1,212	3,083	705	712
16									1,045	2,590	768	752
17									947	2,127	9,705	752
18									1,465	9,705	12,910	675
19									1,490	7,435	6,432	675
20									1,289	3,990	3,945	675
21									975	2,988	2,695	712
22									836	2,454	2,223	752
23									603	2,050	2,065	792
24									471	3,593	1,990	792
25									471	1,592	1,917	792
26									439	1,465	1,392	752
27									409	1,323	1,223	712
28									409	1,300	1,085	603
29									397	1,234	1,085	586
30									421	1,212	1,085	603
31										1,116		675
1904.												
1				8,135	10,140	9,705	645	575	273	478	510	300
2				15,460	7,435	35,860	872	523	284	523	445	273
3				9,705	5,318	5,065	720	966	273	397	397	220
4				6,090	4,267	3,877	660	818	246	328	385	220
5				5,140	3,382	11,590	645	720	273	356	415	220
6				4,575	2,950	6,617	631	645	262	374	385	220
7				4,695	2,556	4,455	938	542	231	210	385	195
8			36,460	4,817	2,255	3,382	845	477	246	246	397	100
9			17,560	6,090	1,945	5,065	736	385	220	220	339	415
10			8,135	17,260	1,805	7,158	760	356	220	246	374	328
11			4,267	10,720	1,644	3,990	2,095	385	246	246	385	328
12			3,990	8,275	1,415	2,988	1,778	374	246	328	385	328
13			3,140	6,090	1,392	2,255	1,477	328	246	660	339	273
14			2,765	4,575	1,300	1,805	1,477	317	220	1,732	317	273
15			2,337	3,765	4,575	1,515	1,005	273	220	1,138	300	273
16			2,065	3,765	8,842	2,337	818	273	220	818	415	278
17			1,697	3,765	5,830	1,945	720	273	220	720	356	220
18			1,917	4,455	4,220	1,440	660	246	220	645	385	220
19			2,127	4,455	16,660	1,212	575	246	220	575	300	246
20			6,697	3,877	13,660	1,106	510	300	210	542	273	273
21			8,985	2,988	8,415	1,005	445	300	170	589	273	328
22			4,695	3,240	5,190	1,085	477	445	146	1,415	273	300
23			21,160	3,340	4,105	1,035	415	760	170	1,415	273	374
24			22,660	3,140	5,065	1,035	736	872	180	1,169	284	328
25			19,060	3,240	4,817	872	784	720	273	1,035	385	328
26			28,060	3,810	3,658	800	610	542	356	845	356	356
27			21,460	3,445	3,810	720	645	445	497	760	373	645
28			10,430	15,760	5,190	683	575	339	477	682	246	7,855
29			6,617	13,960	2,678	645	720	328	477	645	328	4,575
30			5,700	10,720	2,255	645	800	317	477	542	246	2,095
31			5,960		6,352		660	273		445		1,945

Estimated monthly discharge of Chemung River near Chemung, N. Y., for 1903–4.

[Drainage area, 2,440 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1903.					
September 7–30	3,855	397	1,146	0.47	0.42
October	18,460	409	3,981	1.63	1.88
November	12,910	705	2,265	.93	1.04
December	1,791	536	757	.31	.36
1904.					
March 8–31	36,460	1,697	10,331	4.23	3.90
April	17,260	2,988	6,645	2.72	3.03
May	16,660	1,300	4,940	2.02	2.33
June	35,860	645	4,063	1.67	1.86
July	2,095	415	820	3.36	.387
August	966	246	463	.190	.219
September	497	146	267	.109	.122
October	1,732	210	656	.269	.310
November	510	246	347	.142	.158
December	7,855	100	785	.322	.371
The year	36,460	100	2,932	1.20	12.69

SUSQUEHANNA RIVER (WEST BRANCH) AT WILLIAMSPORT, PA.

This station was established March 1, 1895, by George D. Snyder, who was at that time city engineer, and daily gage heights have been recorded since that date. On August 16, 1901, a standard chain gage was installed on the upper side of Market Street Bridge by E. G. Paul. The length of the chain from the end of the weight to the marker is 40.29 feet. The bench mark is a cut in the face of the left abutment 10.07 feet above gage datum. Discharge measurements are made from the lower side of the bridge. The initial point for soundings is the face of the abutment on the left bank. The channel is straight for several hundred feet above and below the station, is broken by four bridge piers, and is about 1,000 feet wide at the station. There is a dam about one-half mile above. Both banks are high and rocky. The bed of the stream is composed of gravel and silt, and will probably change to some extent in the shore spans. The current velocity is sufficient for accurate measurement except at extreme low stages. During nearly ten years, from March, 1895, to January, 1905, the range of gage height at this station has been 21.3 feet, and the estimated maximum and minimum discharges have been 164,100 and 410 cubic feet per second, respectively. The gage is read once each day by

Henry H. Guise, who is employed in the city engineer's office. All records and estimates for this station for years prior to 1905 have been revised and republished in Water-Supply Paper No. 109.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Susquehanna River (West Branch) at Williamsport, Pa., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Sq. feet.	*Ft. per sec.*	*Feet.*	*Second-feet.*
July 19	R. J. Taylor	3,874	1.09	2.07	4,220
September 14	J. C. Hoyt	2,550	0.53	0.52	1,340
September 30	do	3,040	0.67	1.10	2,060

Mean daily gage height, in feet, of Susquehanna River (West Branch) at Williamsport, Pa., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.2	3.8	2.7	6.2	7.8	3.6	2.3	1.0	0.4	0.8	1.0	0.6
2	2.2	3.4	7.0	16.8	7.0	3.7	2.1	.9	.4	1.0	1.0	.5
3	2.0	3.0	7.5	13.6	6.2	3.7	1.9	.9	.4	1.0	1.0	.5
4	2.0	2.8	19.0	9.8	5.5	3.5	1.7	.9	.3	.9	1.0	.4
5	1.8	3.0	16.5	8.0	5.0	6.1	1.5	.8	.3	.8	.9	a.4
6	1.8	2.4	9.2	6.8	4.5	4.5	1.5	.7	.3	.8	.9	.4
7	1.7	2.6	7.4	6.4	4.2	3.7	1.7	.7	.2	.7	.8	.4
8	1.7	b5.0	17.4	6.0	3.9	3.4	1.8	.7	.2	.7	.7	.4
9	1.7	c10.5	13.5	6.0	3.6	3.2	3.4	.6	.2	.6	.6	.4
10	1.7	c7.6	9.8	8.8	3.3	3.2	4.4	.5	.2	.6	.6	.4
11	1.7	c6.0	7.6	9.2	3.2	3.3	8.1	.5	.2	.6	.7	a4
12	1.7	c5.2	6.5	7.9	3.0	3.3	6.7	.4	.5	.5	.7	.4
13	1.7	c4.3	5.8	7.2	2.8	2.9	5.4	.4	.6	.7	.7	.3
14	1.7	3.8	5.3	6.6	2.5	2.7	4.6	.5	.5	1.2	.8	.3
15	1.6	4.0	5.0	5.8	3.0	2.4	3.8	.5	.5	1.5	.8	.3
16	1.6	d3.8	4.4	5.2	3.4	2.6	3.4	.5	.6	1.4	.7	.3
17	1.5	d3.6	4.1	5.2	3.3	3.1	3.0	.3	.5	1.3	.7	.3
18	1.5	d3.5	3.8	5.1	3.2	2.8	2.5	.3	.5	1.2	.7	.2
19	1.5	3.8	4.0	5.0	4.7	2.6	2.1	.3	.4	1.1	.7	.2
20	1.5	d3.0	4.5	4.5	7.7	2.3	2.0	.4	.3	1.0	.7	.2
21	1.4	2.9	6.5	4.2	7.2	2.3	1.7	.5	.3	1.1	.6	.2
22	1.5	2.8	6.7	3.9	6.0	3.0	1.5	.5	.2	1.5	.6	.2
23	7.7	2.7	6.6	3.6	5.2	3.7	1.3	.9	.2	1.7	.6	.2
24	13.3	3.7	e9.9	3.3	4.7	4.0	1.3	1.0	.2	1.6	.7	.3
25	9.8	4.2	10.3	3.2	4.4	3.2	1.2	1.2	.2	1.5	.6	.3
26	7.0	3.8	11.3	3.6	4.2	2.8	1.1	1.0	.3	1.5	.6	.3
27	5.4	3.0	f12.6	4.3	4.0	2.3	1.1	.9	.6	1.4	.6	.4
28	4.9	2.7	10.6	5.1	3.8	2.1	1.1	.7	1.0	1.3	.6	1.8
29	3.	2.5	8.0	6.8	3.5	1.9	1.1	.6	1.0	1.3	.5	5.4
30	3.2	.....	6.9	8.4	3.3	1.7	1.0	.6	1.1	1.2	.5	5.5
31	3.6	.....	6.0	.....	3.3	.....	1.0	.5	.....	1.1	.....	4.4

a River frozen December 5 to 28, 1904.
b Ice running.
c Slush ice running.
d Anchor ice running.
e Noon river 18 feet.
f Extreme height.

Rating table for Susquehanna River (West Branch) at Williamsport, Pa., from 1895 to 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
—0.2	410	2.2	4,530	6.0	18,330	10.6	47,400
.0	600	2.3	4,770	6.2	19,330	10.8	49,000
.1	710	2.4	5,010	6.4	20,340	11.0	50,600
.2	830	2.5	5,250	6.6	21,360	11.2	52,200
.3	970	2.6	5,500	6.8	22,380	11.4	53,800
.4	1,120	2.7	5,760	7.0	23,400	11.6	55,500
.5	1,280	2.8	6,020	7.2	24,600	11.8	57,200
.6	1,440	2.9	6,300	7.4	25,700	12.0	58,900
.7	1,610	3.0	6,580	7.6	26,900	12.2	60,700
.8	1,780	3.2	7,170	7.8	28,100	12.4	62,500
.9	1,960	3.4	7,780	8.0	29,300	12.6	64,300
1.0	2,140	3.6	8,400	8.2	30,500	12.8	66,100
1.1	2,320	3.8	9,030	8.4	31,800	13.0	67,900
1.2	2,510	4.0	9,690	8.6	33,100	13.2	69,800
1.3	2,700	4.2	10,400	8.8	34,400	13.4	71,700
1.4	2,890	4.4	11,150	9.0	35,800	13.6	73,600
1.5	3,080	4.6	11,940	9.2	37,200	13.8	75,500
1.6	3,270	4.8	12,750	9.4	38,600	14.0	77,500
1.7	3,460	5.0	13,600	9.6	40,000	14.5	82,600
1.8	3,660	5.2	14,500	9.8	41,400	15.0	87,800
1.9	3,860	5.4	15,420	10.0	42,800		
2.0	4,070	5.6	16,370	10.2	44,300		
2.1	4,300	5.8	17,340	10.4	45,800		

Mean daily discharge, in second-feet, of Susquehanna River (West Branch) at Williamsport, Pa., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4,530	9,030	5,760	19,330	28,100	8,400	4,770	2,140	1,120	1,780	2,140	1,440
2	4,530	7,780	23,400	107,800	23,400	8,710	4,300	1,960	1,120	2,140	2,140	1,280
3	4,070	6,580	26,300	73,600	19,330	8,710	3,860	1,960	1,120	2,140	2,140	1,280
4	4,070	6,020	135,100	41,400	15,890	8,090	3,460	1,960	970	1,960	2,140	1,120
5	3,660	6,580	104,300	29,300	13,600	18,830	3,080	1,780	970	1,780	1,960	1,120
6	3,660	5,010	37,200	22,380	11,540	11,540	3,080	1,610	970	1,780	1,960	1,120
7	3,460	5,500	25,700	20,340	10,400	8,710	3,460	1,610	830	1,610	1,780	1,120
8	3,460	13,600	115,000	18,330	9,360	7,780	3,660	1,610	830	1,610	1,610	1,120
9	3,460	46,600	72,600	18,330	8,400	7,170	7,780	1,440	830	1,440	1,440	1,120
10	3,460	26,900	41,400	34,400	7,470	7,170	11,150	1,280	830	1,440	1,440	1,120
11	3,460	18,330	26,900	37,200	7,170	7,470	29,950	1,280	830	1,440	1,610	1,120
12	3,460	14,500	20,850	28,700	6,580	7,470	21,870	1,120	1,280	1,280	1,610	1,120
13	3,460	10,770	17,340	24,600	6,020	6,300	15,420	1,120	1,440	1,610	1,610	970
14	3,460	9,030	14,960	21,360	5,250	5,760	11,940	1,280	1,280	2,510	1,780	970

Mean daily discharge, in second-feet, of Susquehanna River (West Branch) at Williamsport, Pa., for 1904—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
15	3,270	9,690	13,600	17,340	6,580	5,010	9,030	1,280	1,280	3,080	1,780	970
16	3,270	9,080	11,150	14,500	7,780	5,500	7,780	1,280	1,440	2,890	1,610	970
17	3,080	8,400	10,040	14,500	7,470	6,870	6,580	970	1,280	2,700	1,610	970
18	3,080	8,090	9,080	14,050	7,170	6,020	5,250	970	1,280	2,510	1,610	830
19	3,080	7,470	9,690	13,600	12,340	5,500	4,300	970	1,120	2,320	1,610	830
20	3,080	6,580	11,540	11,540	27,500	4,770	4,070	1,120	970	2,140	1,610	830
21	2,890	6,300	20,850	10,400	24,600	4,770	3,460	1,280	970	2,320	1,440	830
22	3,080	6,020	21,870	9,360	18,330	6,580	3,080	1,280	830	3,080	1,440	830
23	27,500	5,760	21,360	8,400	14,500	8,710	2,700	1,960	830	3,460	1,440	830
24	70,700	8,710	42,100	7,470	12,340	9,690	2,700	2,140	830	3,270	1,610	970
25	41,400	10,400	45,000	7,170	11,150	7,170	2,510	2,510	830	3,080	1,440	970
26	23,400	9,030	53,000	8,400	10,400	6,020	2,320	2,140	970	3,080	1,440	970
27	15,420	6,580	64,300	10,770	9,690	4,770	2,320	1,960	1,440	2,890	1,440	1,120
28	13,170	5,760	47,400	14,050	9,030	4,300	2,320	1,610	2,140	2,700	1,440	3,660
29	8,090	5,250	29,300	22,380	8,090	3,860	2,320	1,440	2,140	2,700	1,280	7,640
30	7,170	.....	22,890	31,800	7,470	3,460	2,140	1,440	2,320	2,510	1,280	8,010
31	8,400	.....	18,330	.....	7,470	.....	2,140	1,280	.....	2,320	.....	4,220

Estimated monthly discharge of Susquehanna River (West Branch) at Williamsport, Pa., for 1904.

[Drainage area, 5,640 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	70,700	2,890	9,477	1.68	1.94
February	46,600	5,010	10,320	1.83	1.97
March	135,100	5,760	36,070	6.40	7.38
April	107,800	7,170	23,760	4.21	4.70
May	28,100	5,250	12,080	2.14	2.47
June	18,830	3,460	7,170	1.27	1.42
July	29,950	2,140	6,219	1.10	1.27
August	2,510	970	1,541	.273	.315
September	2,320	830	1,170	.207	.231
October	3,460	1,280	2,309	.409	.472
November	2,140	1,280	1,648	.292	.326
December	8,010	1,120	1,660	.294	.339
The year	135,100	830	9,450	1.68	22.83

JUNIATA RIVER AT NEWPORT, PA.

This station, which is about 15 miles above the mouth of the river, was established March 21, 1899, by E. G. Paul. The standard chain gage has until the autumn of 1904 been located on the covered wagon bridge, 800 feet east of the public square at Newport, Pa. In the latter part of 1904 this bridge was removed and a steel structure will be erected on the same site. A standard chain gage will be attached to the new bridge immediately after its completion. In the meantime a temporary vertical staff gage, which has the same datum as the bench mark, has been attached to the exposed end of a sewer which discharges near the bridge, and the daily record of stage of river has been kept continuously. Bench mark No. 1 is on the extreme east end of the stone doorsill, east front of Ewing's store building, near end of bridge. The elevation above gage datum is 28.83 feet. Bench mark No. 2 is on shelf in southeast corner of underpinning of store of J. M. Ewing. elevation 27.37 feet above gage datum. This is a bench mark of the Pennsylvania Railroad and according to their levels is 390.69 feet above sea level. Discharge measurements have been made from the lower side of the wagon bridge to which the gage was attached. The channel is straight for one-half mile above and below the station. Both banks are high and are not subject to overflow. There is a single channel broken by three bridge piers. The piers do not interfere with the flow of the stream and there is little eddying and boiling near them. The bed is of hard material and is probably permanent. There is a good measurable velocity at all stages.

During nearly five years the range in gage height has been 22.8 feet, and the estimated maximum and minimum discharge has been 292,500 and 230 cubic feet per second, respectively.

The gage is read once each day by A. R. Bortel. All records and estimates for this station for years prior to 1905 have been revised and republished in Water-Supply Paper No. 109.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Juniata River at Newport, Pa., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
1904.		*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
July 16	N. C. Grover	1,520	2.73	4.28	4,152

Mean daily gage height, in feet, of Juniata River at Newport, Pa., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.2	4.0	7.5	6.7	6.7	4.9	3.7	3.3	3.0	2.9	2.9	2.5
2	4.2	5.0	12.0	13.4	6.1	5.6	3.7	3.3	3.0	2.9	2.9	2.8
3	4.5	5.0	7.2	9.4	5.7	6.0	3.7	3.7	3.0	2.9	2.9	2.9
4	4.6	5.0	13.5	7.7	5.3	5.4	3.7	3.6	3.0	2.9	2.9	3.2
5	4.6	8.0	8.9	6.7	5.0	5.9	3.7	3.6	3.0	2.9	2.9	2.9
6	4.6	8.5	6.0	5.7	4.8	5.9	3.7	3.5	3.0	2.9	2.8	3.1
7	4.6	11.5	5.5	5.7	4.7	5.4	4.4	3.9	2.9	2.9	2.8	3.2
8	4.5	8.5	14.0	5.3	4.6	4.7	5.1	3.5	2.9	2.9	2.8	3.2
9	4.5	6.5	10.0	5.3	4.5	4.6	5.8	3.3	3.0	2.9	2.8	3.2
10	4.5	5.0	7.2	6.3	4.4	4.5	7.2	3.3	3.0	2.9	2.8	3.1
11	4.4	4.6	6.0	6.3	4.3	5.1	8.7	3.2	3.0	2.9	2.9	3.1
12	4.2	4.2	6.0	6.0	4.2	4.6	7.1	3.2	3.0	2.9	2.9	3.1
13	4.1	4.0	5.2	5.7	4.2	4.4	5.5	3.1	3.0	2.9	2.9	3.1
14	4.1	3.9	5.2	5.3	4.2	4.2	5.3	3.1	2.9	2.9	2.9	3.1
15	4.1	4.1	5.0	5.0	4.2	4.0	4.7	3.1	2.9	2.9	2.9	3.1
16	4.1	4.2	4.8	4.8	4.2	4.0	4.7	3.1	3.0	2.9	2.9	3.1
17	4.0	4.4	4.5	4.8	4.2	4.4	4.1	3.0	3.0	2.9	2.9	3.1
18	4.0	5.0	4.5	4.7	4.3	3.9	3.9	3.2	3.0	2.9	2.9	3.1
19	4.0	4.6	4.8	4.4	4.5	3.9	3.8	3.1	3.0	2.9	2.9	3.1
20	4.0	4.7	4.5	4.4	6.7	3.9	3.9	3.2	2.9	2.9	2.8	3.1
21	4.0	4.7	5.8	4.3	5.9	3.7	3.7	3.2	2.9	3.3	2.8	3.1
22	4.0	5.0	5.5	4.2	5.5	5.7	3.6	3.2	2.9	3.3	2.8	3.1
23	5.4	5.0	5.8	4.2	4.9	5.5	3.5	3.2	2.9	3.2	2.8	3.1
24	[a]11.0	5.4	8.0	4.0	4.6	5.3	3.8	3.2	2.9	3.1	2.7	3.2
25	7.0	7.2	7.5	4.0	4.5	4.4	3.8	3.1	2.9	3.1	2.7	3.2
26	5.5	7.4	6.9	4.0	4.6	4.0	3.7	3.1	2.9	3.0	2.7	3.2
27	4.5	5.9	6.2	4.2	4.7	3.5	3.7	3.0	2.9	2.9	2.7	3.5
28	4.1	4.8	6.2	4.6	4.5	3.8	3.5	3.0	2.9	2.9	2.6	3.7
29	3.8	4.5	5.6	6.5	4.4	3.7	3.4	3.1	2.9	2.9	2.6	3.8
30	3.7	.....	5.2	7.5	4.2	3.7	3.3	3.1	2.9	2.9	2.5	3.8
31	3.8	.....	5.0	.....	4.6	.....	3.3	3.0	.....	2.9	.....	3.8

[a] Ice moved out.

Rating table for Juniata River at Newport, Pa., from 1899 to 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.5	230	4.7	5,180	6.9	14,570	10.2	38,500
2.6	320	4.8	5,510	7.0	15,170	10.4	40,300
2.7	430	4.9	5,850	7.1	15,770	10.6	42,200
2.8	570	5.0	6,200	7.2	16,370	10.8	44,100
2.9	750	5.1	6,550	7.3	16,970	11.0	46,000
3.0	950	5.2	6,910	7.4	17,570	11.2	48,000
3.1	1,160	5.3	7,270	7.5	18,170	11.4	50,100
3.2	1,370	5.4	7,640	7.6	18,770	11.6	52,200
3.3	1,580	5.5	8,010	7.7	19,380	11.8	54,300
3.4	1,790	5.6	8,390	7.8	20,000	12.0	56,400
3.5	2,000	5.7	8,770	7.9	20,640	12.2	58,600
3.6	2,210	5.8	9,150	8.0	21,300	12.4	60,800
3.7	2,430	5.9	9,540	8.2	22,700	12.6	63,100
3.8	2,650	6.0	9,930	8.4	24,100	12.8	65,400
3.9	2,880	6.1	10,330	8.6	25,500	13.0	67,700
4.0	3,120	6.2	10,740	8.8	27,000	13.2	70,100
4.1	3,380	6.3	11,200	9.0	28,500	13.4	72,600
4.2	3,650	6.4	11,720	9.2	30,100	13.6	75,100
4.3	3,930	6.5	12,270	9.4	31,700	13.8	77,600
4.4	4,220	6.6	12,830	9.6	33,400		
4.5	4,530	6.7	13,400	9.8	35,100		
4.6	4,850	6.8	13,980	10.0	36,800		

Mean daily discharge, in second-feet, of Juniata River at Newport, Pa., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3,650	3,120	18,170	13,400	13,400	5,850	2,430	1,580	950	750	750	230
2	3,650	6,200	56,400	72,600	10,330	8,390	2,430	1,580	950	750	750	570
3	4,530	6,200	16,370	31,700	8,770	9,930	2,430	2,430	950	750	750	750
4	4,850	6,200	73,850	19,380	7,270	7,640	2,430	2,210	950	750	750	1,370
5	4,850	21,300	27,700	13,400	6,200	9,540	2,430	2,210	950	750	750	750
6	4,850	24,800	9,930	8,770	5,510	9,540	2,430	2,000	950	750	570	1,160
7	4,850	51,100	8,010	8,770	5,180	7,640	4,220	2,880	750	750	570	1,370
8	4,530	24,800	80,100	7,270	4,850	5,180	6,550	2,000	750	750	570	1,370
9	4,530	12,270	36,800	7,270	4,530	4,850	9,150	1,580	950	750	570	1,370
10	4,530	6,200	16,370	11,200	4,220	4,530	16,370	1,580	950	750	570	1,160
11	4,220	4,850	9,930	11,200	3,930	6,550	26,200	1,370	950	750	750	1,160
12	3,650	3,650	9,930	9,930	3,650	4,850	15,770	1,370	950	750	750	1,160
13	3,380	3,120	6,910	8,770	3,650	4,220	8,010	1,160	950	750	750	1,160
14	3,380	2,880	6,910	7,270	3,650	3,650	7,270	1,160	750	750	750	1,160
15	3,380	3,380	6,200	6,200	3,650	3,120	5,180	1,160	750	750	750	1,160
16	3,380	3,650	5,510	5,510	3,650	3,120	5,180	1,160	950	750	750	1,160
17	3,120	4,220	4,530	5,510	3,650	4,200	3,380	950	950	750	750	1,160

Mean daily discharge, in second-feet, of Juniata River at Newport, Pa., for 1904—Cont'd.

Day.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
18	3,120	6,200	4,530	5,180	3,930	2,880	2,880	1,370	950	750	750	1,160
19	3,120	4,850	5,510	4,220	4,530	2,880	2,650	1,160	950	750	750	1,160
20	3,120	5,180	4,530	4,220	13,400	2,880	2,880	1,370	750	750	570	1,160
21	3,120	5,180	9,150	3,930	9,540	2,430	2,430	1,370	750	1,580	570	1,160
22	3,120	6,200	8,010	3,650	8,010	8,770	2,210	1,370	750	1,580	570	1,160
23	7,640	6,200	9,150	3,650	5,850	8,010	2,000	1,370	750	1,370	570	1,160
24	46,000	7,640	21,300	3,120	4,850	7,270	2,650	1,370	750	1,160	430	1,370
25	15,170	16,370	18,170	3,120	4,530	4,220	2,650	1,160	750	1,160	430	1,370
26	8,010	17,570	14,570	3,120	4,850	3,120	2,430	1,160	750	950	430	1,370
27	4,530	9,540	10,740	3,650	5,180	2,000	2,430	950	750	750	430	2,000
28	3,380	5,510	10,740	4,850	4,530	2,650	2,000	950	750	750	320	2,430
29	2,650	4,530	8,390	12,270	4,220	2,430	1,790	1,160	750	750	320	2,650
30	2,430	.....	6,910	18,170	3,650	2,430	1,580	1,160	750	750	230	2,650
31	2,650	.....	6,200	.....	4,850	.....	1,580	950	.....	750	.....	2,650

Estimated monthly discharge of Juniata River at Newport, Pa., for 1904.

[Drainage area, 3,476 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January[a]	46,000	2,430	5,722	1.65	1.90
February	51,100	2,880	9,756	2.81	3.03
March	80,100	4,530	17,150	4.93	5.68
April	72,600	3,120	10,710	3.08	3.44
May	13,400	3,650	5,742	1.65	1.90
June	9,930	2,000	5,160	1.48	1.65
July	26,200	1,580	4,968	1.43	1.65
August	2,880	950	1,460	.420	.484
September	950	750	850	.245	.273
October	1,580	750	856	.246	.284
November	750	230	607	.175	.195
December	2,650	230	1,344	.386	.445
The year	80,100	230	5,360	1.54	20.93

[a] Frozen January 1 to 23. Rating table assumed to apply correctly.

BROAD CREEK AT MILL GREEN, MD.

The basin of this creek lies wholly in Harford County, Md. It is generally hilly and is composed of farming lands. It is tributary to Susquehanna River at a point a few miles above the fall line. This station was established on December 14, 1904, by F. H. Tillinghast, and is best reached from Cardiff, Md. A standard chain gage is attached to a steel highway bridge in the village of Mill Green; the

length of chain from the end of the weight to the marker is 14.97 feet. Gage datum is referred to bench marks as follows: 1. Chiseled square on upstream end of right abutment; elevation, 10.60 feet. 2. Top of chord of bridge directly over pulley of gage; elevation, 16.31 feet. 3. Nail in large blazed tree about 100 feet upstream from bridge on left bank; elevation, 12.83 feet. All elevations are above the datum of the gage. The channel is straight for 200 feet above and 500 feet below the station. The bed is rough and the velocity of the current at the bridge is small at low stages of the stream. Low-water measurements may be made by wading at a point about 100 feet above the station. The gage is read twice daily by James F. Snodgrass.

The maintenance of this station during 1904 was under the direction of N. C. Grover, district hydrographer.

DEER CREEK NEAR CHURCHVILLE, MD.

This creek has its headwaters in York County, Pa., flows southeasterly through Baltimore and Harford counties, Md., and is tributary to Susquehanna River opposite Port Deposit. Its basin is hilly and generally in farming lands. Slopes are steep, and at several places small power plants are in use. This station was established December 14, 1904, by F. H. Tillinghast, and is best reached by driving from Belair. A standard chain gage is attached to the highway bridge on the Deer Creek road about 3 miles north from Churchville. The length of chain from the end of the weight to the marker is 15.20 feet. The datum of the gage is referenced by the following bench marks: 1. Chiseled square on the downstream end of the right abutment; elevation, 14.10 feet. 2. Top of eyebar of bottom chord in middle of second panel from the right bank; elevation, 14.68 feet. The channel is straight for 500 feet above and below the station. The bed is generally smooth, is composed of sand, with a few bowlders, and is practically permanent. The current has a good velocity at all stages. The gage is read twice daily, by Harris Archer.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer, and the following measurement was made November 8: Width, 70 feet; area of section, 86 square feet; mean velocity, .85 feet per second; gage height, 1.48 feet; discharge, 73 second-feet.

GUNPOWDER RIVER DRAINAGE BASIN.

The headwaters of Gunpowder River lie in York County, Pa., near the Maryland line. Thence the river flows southeasterly through Baltimore County, Md., and empties into Chesapeake Bay about 10 miles northeast of Baltimore. The river, although small, has steep

slopes, and the powers have considerable value on account of the small distance to a large city. A portion of the water supply for Baltimore is taken from this river at Loch Raven, and the city has purchased all power rights below this place. As the city increases in size it is probable that a larger proportion of the flow of the river will be taken. Little Gunpowder Falls, which is tributary below the fall line, has the same general characteristics as the larger river. Throughout its entire length it forms the boundary line between Harford and Baltimore counties, Md. There are several small power developments.

GUNPOWDER FALLS AT GLENCOE, MD.

This station was established on December 15, 1904, by F. H. Tillinghast. It is located at a steel highway bridge near the Pennsylvania Railroad station of Glencoe. A standard chain gage is attached to the upstream truss of the bridge. The length of the chain from the end of the weight to the marker is 22.13 feet. It is referenced by bench marks as follows: (1) Chiseled cross on downstream corner of left abutment; elevation, 18.30 feet. (2) Top of iron standard of gate at railroad crossing nearest bridge; elevation, 19.77 feet. The channel is straight for a distance of 300 feet above and 300 feet below the station. The bed is smooth and of sand, shifting slightly. The velocity of the current is good at all stages of the river. The gage is read twice daily by Samuel Wilhelm, the station agent at Glencoe.

The maintenance of this station during 1904 was under the direction of N. C. Grover, district hydrographer.

LITTLE GUNPOWDER FALLS NEAR BELAIR, MD.

This station was established on December 13, 1904, by F. H. Tillinghast. A standard chain gage is attached to a steel highway bridge on the road from Belair to Kingsville and at a distance of about 9 miles from Belair, from which place it is best reached by livery. The length of chain from the end of the weight to the marker is 13.36 feet. Its datum is referred to bench marks as follows: 1. Chiseled square on downstream end of right abutment; elevation, 13.36 feet. 2. Top of pulley wheel; elevation, 12.96 feet. The measurements are made from the upstream side of the bridge to which the gage is attached. The channel is straight for 300 feet above and 100 feet below the station. The bed is sand, with bowlders, and may shift slightly in the sand. The velocity of the current is good at all stages. There is a flood plain about 100 feet wide on the right bank. The gage is read twice daily by A. D. Unkart.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Little Gunpowder Falls, near Belair, Md., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet*
November 8 ...	N. C. Grover	33	27	1.22	1.40	3
November 30 ..	.....do	27.5	30	1.27	1.46	3

PATAPSCO RIVER DRAINAGE BASIN.

Patapsco River is formed by the junction of the North Branch and the South, or Piney Branch, near Mariottsville, Md., and flows in a southeasterly direction into Chesapeake Bay 13 miles south of Baltimore. Both branches rise in the central part of Maryland, and the whole basin, which has an area of about 350 square miles, lies within that State.

The river carries a small volume of water, but has considerable slope, so that a large number of water powers have been developed along its course. These, although small, are made valuable by their proximity to a large city.

The drainage basin is hilly and largely under cultivation. It has no lakes or artificial reservoirs, and the flow of the stream is variable. The maximum estimated flow at the gaging station at Woodstock, Md., where the drainage area is 250 square miles, is about 12,000 cubic feet per second, while the minimum estimated flow has been about 70 cubic feet per second. The record from which these estimates have been taken extends over a period of eight and one-half years. The freshets do not, however, cause very large rises of the water, because of the steep slope of the stream. The maximum recorded difference in gage height at Woodstock has been 13 feet, while the usual range within a year is about 3 or 4 feet.

The bed is generally rock. The banks are of rock and very little land is subject to overflow. The Baltimore and Ohio Railroad follows the stream closely throughout nearly its entire length.

PATAPSCO RIVER AT WOODSTOCK, MD.

This station was established August 6, 1896, by E. G. Paul. The original wire gage was destroyed when the bridge was repaired January 20–25, 1899. A new wire gage was established January 30, 1899, on the same datum. A standard chain gage was installed by W. C. Sawyer, November 11, 1903, on the upper side of the bridge. The datum was not changed. The length of the chain from the end of the weight to the marker is 28.28 feet. The bench mark is a United States Geological Survey standard copper bolt set in the face of the

retaining wall at the entrance to the college grounds at the north end of the bridge. Its elevation is 22.06 feet above gage datum. Discharge measurements are made from the upper side of the iron highway bridge to which the gage is attached. It is located 1½ miles below the junction with the North Branch and near the railroad station. The initial point for soundings is near the right bank. The channel is straight for 150 feet above and several hundred feet below the station. At ordinary stages the river flows in one channel 100 feet wide; at high stages it flows in two channels 220 feet wide. The velocity is rapid. Both banks are high and are not subject to overflow. The right bank is without trees; the left is wooded. The bed of the stream is rough and is composed of bowlders and cobblestones. It is subject to slight change at extreme high water.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Patapsco River at Woodstock, Md., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
July 12	Grover and Hoyt	102	89	2.02	3.91	180
September 30	E. C. Murphy	59	34	1.18	3.25	40
September 30 [a]	do	43	23	1.74	3.25	40

[a] Wading ¼ mile above.

Mean daily gage height, in feet, of Patapsco River at Woodstock, Md., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.95	3.95	4.00	4.15	3.60	3.65	3.60	3.65	3.40	3.45	3.60	3.65
2	3.95	3.90	4.00	4.15	3.75	3.50	3.60	3.60	3.45	3.40	3.50	3.55
3	3.95	3.90	4.00	3.95	3.75	3.70	3.55	3.90	3.35	3.40	3.45	3.60
4	[a] 4.00	3.85	4.00	3.90	3.70	3.65	3.40	3.75	3.55	3.35	3.40	3.60
5	[a] 4.60	3.85	4.00	3.85	3.75	3.50	3.50	3.75	3.50	3.35	3.40	3.65
6	[a] 4.00	3.85	4.00	3.75	3.65	4.10	3.45	3.70	3.40	3.50	3.50	3.55
7	[a] 4.00	5.75	4.00	4.00	3.75	3.85	3.80	3.60	3.40	3.40	3.45	3.50
8	[a] 4.00	3.85	5.65	3.95	3.55	3.75	5.15	3.55	3.40	3.45	3.45	3.65
9	[a] 4.00	3.75	5.10	4.10	3.75	3.60	4.05	3.50	3.35	3.45	3.60	3.55
10	[a] 4.00	3.75	4.90	3.85	3.90	3.65	3.60	3.55	3.35	3.45	3.55	3.35
11	[a] 4.00	3.75	4.45	3.90	3.75	3.80	4.10	3.55	3.30	3.50	4.10	3.70
12	[a] 4.00	3.75	4.35	3.85	3.70	3.45	[b] 5.55	3.70	3.40	4.05	3.70	3.65
13	(a)	3.75	4.10	3.75	3.65	3.75	4.75	3.40	3.45	4.00	3.85	3.85
14	(a)	3.70	3.95	3.80	3.70	3.55	3.80	3.45	3.70	3.75	4.10	3.85
15	(a)	3.70	4.05	3.70	4.20	3.60	3.65	3.45	5.05	3.70	4.00	3.90
16	(a)	3.70	4.10	3.85	3.90	3.50	3.55	3.35	3.85	3.55	3.95	4.05
17	(a)	3.70	3.90	3.70	3.65	3.70	3.50	3.55	3.45	3.50	3.85	4.00
18	(a)	3.80	4.10	3.80	3.70	3.60	3.55	3.60	3.35	3.50	3.80	4.05
19	(a)	3.80	4.05	3.75	4.00	3.60	3.60	3.50	3.55	3.45	3.85	4.10
20	(a)	3.85	4.10	3.70	3.75	3.65	3.55	4.15	3.50	3.50	3.80	4.00
21	(a)	4.00	4.10	3.70	3.70	3.60	3.50	3.85	3.55	5.35	3.80	3.95
22	[c] 7.05	11.30	4.20	3.75	3.55	3.60	3.50	3.95	3.50	4.00	3.70	4.00

[a] Ice. [b] Maximum height 7.3. [c] Breaking up of ice. Maximum gage height 10.1.

Mean daily gage height, in feet, of Patapsco River at Woodstock, Md., for 1904—Cont'd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
23	7.10	4.75	4.20	3.70	3.70	3.50	3.50	3.80	3.55	3.60	3.60	4.1
24	4.05	4.05	4.10	3.65	3.75	3.45	3.75	3.65	3.45	3.55	3.60	4.1
25	4.05	4.05	4.00	3.85	3.60	3.30	3.90	3.50	3.45	3.50	3.50	4.2
26	4.05	4.05	4.05	3.75	3.60	3.55	3.60	3.55	3.45	3.50	3.50	4.1
27	4.05	4.05	4.00	3.85	3.60	3.65	3.55	3.55	3.55	3.55	3.65	4.0
28	4.05	4.05	3.95	3.90	3.60	3.55	3.60	3.40	3.50	3.45	3.55	3.5
29	4.05	4.05	3.85	4.00	3.45	3.55	3.55	3.35	3.45	3.45	3.60	4.0
30	3.95	.....	3.95	3.80	3.55	3.50	3.60	3.40	3.50	3.45	3.60	4.2
31	4.00	.....	4.05	.....	3.75	.....	3.55	3.35	.....	3.60	.....	4.2

POTOMAC RIVER DRAINAGE BASIN.

Potomac River, which drains a total area of about 14,500 square miles, is formed by the junction of the North and South branches about 15 miles below Cumberland, Md., thence it pursues a southeasterly course, forming for its entire length the southerly boundary for the State of Maryland and the northerly boundaries for the States of West Virginia and Virginia, and empties into Chesapeake Bay.

The North Branch rises in the Alleghenies near the western corner of the State of Maryland, and the South Branch rises in the Alleghenies in Virginia and West Virginia. These branches, with their tributaries and the tributaries of the main stream as far down as Shenandoah River, drain a series of narrow and generally fertile valleys lying between the parallel ranges which make up the system of the Alleghenies in this region. Their slopes are not as a rule very large, and their beds are of gravel and sand. The slopes of their drainage basins are, however, generally very steep, and after a rain the water collects quickly in the rivers. There are few lowlands to overflow and no lakes whatever in the region, consequently these streams, and with them the Potomac River, are subject to very sudden and heavy freshets, while in dry seasons their discharge becomes small. The record of gage height at Point of Rocks, Md., covering a period of nearly ten years, shows a maximum range in gage height of 29 feet, and for several of the years the range has been more than 20 feet in each year. The corresponding maximum and minimum discharges have been estimated at 217,000 and 400 cubic feet per second, respectively.

The slopes of the tributary basin of Shenandoah River are, in many instances, steep, but the valley through which it flows is generally broader and more lands are subject to overflow. The slope of the river itself is usually greater than the slopes of the tributaries above mentioned. As a result the fluctuations in this stream are not so great, having a maximum range of about 19 feet at Millville in ten years, while the average annual fluctuation is 10 feet or less. The

discharge in this period has ranged between 57,000 and 300 cubic feet per second.

From the junction of its two branches below Cumberland, Md., the Potomac cuts through the mountains at nearly right angles. Its valley is narrow, its slope in many places great, the bed is generally gravel and bowlders with ledge rock at a small depth, which often appears at the surface. The banks are generally high and not subject to overflow. It crosses the fall line a few miles above Washington and reaches tidewater at Georgetown. As a water-power stream the principal disadvantage is the wide variability of its flow. All other conditions are favorable. A very insignificant amount of water power has been developed.

The Baltimore and Ohio Railroad follows the river for its entire length, while the Shenandoah Valley Railroad and the Cumberland Valley Railroad cross the stream. The Chesapeake and Ohio Canal follows it from Cumberland to Georgetown.

The United States Weather Bureau maintains river stations in this basin as follows:

Potomac at Cumberland, Md.
Potomac at Harpers Ferry, W. Va.
Shenandoah at Riverton, Va.

During 1904 the United States Geological Survey has maintained gaging stations in this basin as follows:

Potomac at Point of Rocks, Md.
Potomac (North Branch) at Piedmont, W. Va.
Potomac (South Branch) at Springfield, W. Va.
Antietam at Sharpsburg, Md.
Shenandoah at Millville, W. Va.
Shenandoah (South Branch) at Front Royal, Va.
Shenandoah (North Branch) at Riverton, Va.
Monocacy at Frederick, Md.

POTOMAC RIVER (NORTH BRANCH) AT PIEDMONT, W. VA.

This station was established June 27, 1899, by E. G. Paul. It is located at the iron highway bridge connecting Luke, Md., with Piedmont, W. Va. The standard chain gage is attached to the hand rail on the lower side of the bridge in the span next to the right bank. The length of the chain from the end of the weight to the marker is 38.87 feet. The bench mark is the top of a small shoulder in the face of the sandstone ledge which forms the right abutment of the bridge. It is about 4 feet above the ground and 10 feet downstream from the bridge. The point is indicated by an arrow cut in the vertical face of the ledge. Its elevation is 20.40 feet above gage datum. Discharge measurements are made from the lower chord of the bridge to which the gage is attached, from the downstream side. The initial point for soundings is the face of the pier on the right bank. The channel is

straight for 1,200 feet above and 600 feet below the station. The current has a moderate velocity. The right bank is high and rocky and will not overflow. The left bank is low and liable to overflow, but all water passes beneath the bridge. The bed of the stream is composed of gravel and cobblestones, is free from vegetation and is permanent. The gage is read twice each day by Charles H. Beck.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Potomac River (North Branch) at Piedmont, W. Va., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
July 8..	Hoyt & Hall.....	115	158	0.73	2.80	116
September 9 ...	E. C. Murphy	50	21	.62	1.99	13
September 28 ..	.....do	47	27	.74	1.99	20

Mean daily gage height, in feet, of Potomac River (North Branch) at Piedmont, W. Va., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1.....	2.90	3.20	4.70	4.70	4.45	3.95	3.00	2.35	1.90	2.00	2.00	2.10
2.....	2.95	3.05	4.55	5.25	4.20	3.85	3.10	2.55	1.90	2.00	2.00	2.05
3.....	3.00	3.10	4.85	4.75	3.95	3.80	3.05	2.40	2.00	2.05	2.05	2.20
4.....	3.55	3.05	5.55	4.35	3.85	3.70	2.85	2.40	1.85	2.00	2.10	2.30
5.....	3.10	3.05	4.40	4.15	3.75	3.80	2.70	2.40	2.00	1.95	2.10	2.20
6.....	2.95	3.10	4.20	4.00	3.65	3.90	2.65	2.35	2.10	1.95	2.00	2.20
7.....	3.15	6.20	4.65	3.90	3.60	3.75	2.70	2.25	1.90	2 00	2.10	2.25
8.....	3.00	6.10	5.55	3.90	3.50	3.60	2.80	2.20	1.90	2.15	2.10	2.20
9.....	2.90	4.70	4.70	4.30	3.50	3.50	2.80	2.05	1.95	2.10	2.10	2.05
10.....	2.80	4.05	4.30	4.15	3.60	3.60	3.45	2.15	2.10	2.10	2.10	2.00
11.....	2.80	3.80	4.25	3.95	3.45	3.50	3.20	2.20	2.00	2.15	2.20	2.10
12.....	2.80	3.60	4.30	3.85	3.35	3.40	3.05	2.20	2.00	2.20	2.20	2.10
13.....	2.70	3.25	4.05	3.85	3.20	3.25	2.90	2.20	2.00	2.40	2.20	2.20
14.....	2.70	3.35	3.95	3.70	3.20	3.20	2.80	2.20	2.00	2.25	2.20	2.30
15.....	2.60	3.45	3.85	3.70	3.40	3.20	2.70	2.15	2.05	2.20	2.20	2.30
16.....	2.60	3.25	3.65	3.75	3.40	3.00	2.60	2.15	2.10	2.15	2.20	2.30
17.....	2.60	3.05	3.55	3.90	3.20	3.10	2.50	2.20	2.10	2.10	2.20	2.30
18.....	3.15	3.00	3.85	3.80	3.70	3.00	2.45	2.10	2.10	2.05	2.20	2.30
19.....	3.00	3.10	3.95	3.70	5.95	2.90	2.35	2.10	2.10	2.10	2.30	2.30
20.....	2.95	3.00	4.40	3.60	5.00	3.00	2.35	2.15	2.00	2.10	2.30	2.30
21.....	3.80	3.20	4.50	3.50	5.00	3.05	2.50	2.20	2.10	2.20	2.30	2.30
22.....	[a]6.80	4.45	4.95	3.45	4.60	3.60	2.90	2.20	2.15	2.20	2.30	2.30
23.....	6.65	4.25	6.60	3.40	4.25	3.45	3.20	2.20	2.10	2.20	2.30	2.30
24.....	5.30	4.85	5.60	3.35	4.05	3.05	2.90	2.20	2.10	2.20	2.30	2.45
25.....	4.25	4.10	5.05	3.45	3.90	2.90	2.70	2.20	1.90	2.20	2.25	4.30
26.....	4.00	3.70	4.95	3.90	3.75	2.80	2.70	2.10	2.05	2.20	2.25	4.00
27.....	3.55	3.55	4.80	4.65	3.85	2.70	2.60	2.10	2.00	2.10	2.20	4.10
28.....	3.25	3.50	4.40	5.25	3.85	2.75	2.50	1.90	2.00	2.20	2.15	4.80
29.....	3.30	4.75	4.10	4.95	3.60	3.25	2.60	2.00	2.00	2.10	2.10	4.05
30.....	3.40	.....	4.00	4.55	3.50	3.05	2.50	2.00	2.00	2.00	2.10	3.20
31.....	3.25	.....	4.45	.....	3.50	.....	2.40	1.90	.....	2.10	.....	3.20

[a] Ice went out 1.05 p. m.

POTOMAC RIVER AT POINT OF ROCKS, MD.

This station was established by C. C. Babb, February 17, 1895, at the steel highway bridge at Point of Rocks, Md. As originally placed, the gage was located in the third span of the bridge from the north shore. The next year (1896) the wire became rusted and broke frequently, and a new wire gage was placed on the lower side of the first span of the bridge and referred to a different datum. During 1897 there was a further change in the length of the wire of the gage, which was not recorded, and therefore it has been necessary to discard the records during those two years—that is, 1896 and 1897. The length of the cable of the original wire gage was 44.22 feet. The measurements of 1895 are considered correct within themselves, but there was a difference between the datum of that gage and that of the present standard of 0.4 foot, making it necessary to deduct that amount from the gage readings of 1895 in order to reduce them to the present datum.

Since January 25, 1898, there has been no change in the datum of the gage. At that time it was referred to a bench mark, which is a copper bolt in a large capstone on the lower wing wall of the north abutment, about 10 feet from the north end of the first iron truss and 41.75 feet above the datum of the gage. A second bench mark was established in July, 1904. It is a cross chiseled on the lower step of the upstream wing wall on the left bank of the river, being just across the towpath, 15 feet from the canal. Its elevation is 24 feet above gage datum.

A standard chain gage was installed at this station September 2, 1902, to take the place of the wire gage then in use. It is bolted to the guard rail on the lower side of the bridge in the second span from the left bank. The length of the chain from the end of the weight to the marker is 44.22 feet.

Discharge measurements are made from the eight span steel toll bridge to which the gage is attached. The initial point for soundings is the left end of the lower guard rail, 0.4 foot beyond the center of the end pin, on the downstream side of the bridge. The channel is straight for 500 feet above and 200 feet below the station. It is 1,300 feet wide, broken by 7 bridge piers. Both banks overflow only at extremely high water and are not wooded. In the two right spans the bed is composed of mud and is subject to some change; in the other spans the bed is composed of gravel and cobblestones and is permanent. The current does not flow at right angles with the bridge in all of the spans. The gage is read once each day by George H. Hickman.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Potomac River at Point of Rocks, Md., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per. sec.*	*Feet.*	*Second-feet.*
July 11.....	Hoyt and Grover	1,104	6,725	2.50	[a] 3.87	16,830

[a] Gage varied 0.82 during measurements.

Mean daily gage height, in feet, of Potomac River at Point of Rocks, Md., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1.....	1.5	3.0	5.3	2.4	5.6	6.7	1.4	1.4	0.9	0.6	0.6	0.8
2.....	1.5	2.9	4.4	2.6	4.0	7.8	1.3	1.3	.8	.6	.6	.8
3.....	2.0	2.9	4.0	3.0	3.6	5.2	1.3	1.2	.8	.6	.7	.8
4.....	2.3	3.3	3.8	3.5	3.0	4.6	1.3	1.2	.8	.6	.7	.8
5.....	1.8	4.8	4.0	3.1	2.8	4.1	1.2	1.2	.9	.6	.7	.8
6.....	1.5	4.9	4.2	3.5	2.6	5.0	1.5	1.2	1.0	.6	.7	.8
7.....	1.5	4.9	4.5	3.0	2.5	4.4	1.5	1.3	.9	.6	.7	.8
8.....	1.5	3.3	5.0	2.4	2.8	4.0	1.6	1.4	.8	.6	.7	.8
9.....	1.6	3.5	4.8	2.3	2.7	3.6	1.6	1.5	.7	.5	.7	.8
10.....	1.6	5.7	5.4	2.3	2.6	3.2	1.7	1.4	.7	.5	.7	.9
11.....	1.6	5.0	4.5	2.6	2.5	2.8	2.9	1.3	.7	.5	.7	.9
12.....	1.7	3.9	3.8	3.1	2.5	2.6	2.6	1.3	.8	.6	.7	.9
13.....	1.6	3.6	3.3	2.8	2.4	2.5	3.4	1.2	1.0	.7	.7	.9
14.....	1.6	3.5	2.8	2.6	2.3	2.4	3.1	1.2	.9	.7	.8	.9
15.....	1.6	3.4	2.6	2.5	2.2	2.2	3.0	1.1	.9	.6	.8	.9
16.....	1.5	3.8	2.4	2.2	2.2	2.1	2.8	1.1	1.0	.6	.8	.9
17.....	1.5	3.8	2.4	2.1	2.1	2.0	2.4	1.1	1.0	.5	.7	.9
18.....	1.5	3.9	2.2	2.1	2.2	1.8	2.0	1.0	.9	.5	.8	.9
19.....	1.5	3.9	2.1	2.0	2.3	1.6	1.8	1.0	.8	.5	.8	.9
20.....	1.5	3.8	2.2	1.9	3.1	1.5	1.6	1.0	.7	.6	.8	1.0
21.....	1.5	3.8	2.3	1.9	6.2	1.5	1.4	1.0	.8	1.0	.7	1.0
22.....	2.0	4.5	2.4	1.8	4.7	2.5	1.4	.9	1.0	.9	.7	1.0
23.....	4.0	5.6	2.5	1.7	4.0	3.0	1.3	.9	.9	.8	.7	1.0
24.....	5.2	6.0	2.7	1.7	3.6	2.8	1.3	1.0	.8	.7	.7	1.0
25.....	[a] 7.4	6.6	3.7	1.6	3.1	2.5	1.3	1.0	.8	.7	.7	1.2
26.....	5.1	6.6	3.4	1.5	2.8	2.1	1.4	2.0	.8	.7	.7	1.4
27.....	3.6	7.6	3.0	1.6	2.5	1.7	1.4	1.1	.7	.7	.7	1.5
28.....	3.3	6.6	2.8	2.0	2.4	1.5	1.4	1.1	.7	.7	.7	1.8
29.....	3.2	6.0	2.6	3.7	2.3	1.5	1.5	1.0	.7	.6	.8	1.8
30.....	3.0	.....	2.5	6.3	2.2	1.4	1.5	1.0	.7	.6	.8	1.9
31.....	3.0	.....	2.4	.....	2.4	.....	1.5	.9	.....	.6	.....	2.0

[a] Ice gorge caused river to rise.

Rating table for Potomac River at Point of Rocks, Md., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.50	1,300	1.80	5,590	3.00	11,455	5.20	23,660
.60	1,345	1.90	6,070	3.10	11,950	5.40	24,970
.70	1,445	2.00	6,550	3.20	12,450	5.60	26,320
.80	1,640	2.10	7,035	3.40	13,470	5.80	27,710
.90	1,900	2.20	7,520	3.60	14,500	6.00	29,140
1.00	2,200	2.30	8,005	3.80	15,550	6.50	32,790
1.10	2,550	2.40	8,490	4.00	16,620	7.00	36,440
1.20	2,935	2.50	8,980	4.20	17,710	7.50	40,290
1.30	3,340	2.60	9,475	4.40	18,820	8.00	44,140
1.40	3,760	2.70	9,970	4.60	19,970	9.00	52,240
1.50	4,195	2.80	10,465	4.80	21,160	10.00	60,540
1.60	4,645	2.90	10,960	5.00	22,390	11.00	68,940
1.70	5,110						

The above table is applicable only for open-channel conditions. It is based upon discharge measurements made during 1900 to 1904, inclusive. It is not very well defined. Above gage height 10 feet the rating curve is a tangent, the difference being 840 per tenth.

Estimated monthly discharge of Potomac River at Point of Rocks, Md., for 1904.

[Drainage area, 9,654 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	39,520	4,195	8,757	0.907	1.05
February	41,060	10,960	20,180	2.09	2.25
March	24,970	7,035	13,460	1.39	1.60
April	31,330	4,195	9,270	.960	1.07
May	30,600	7,035	11,540	1.20	1.38
June	42,600	3,760	12,120	1.26	1.41
July	13,470	2,935	5,612	.581	.670
August	6,550	1,900	2,872	.297	.342
September	2,200	1,445	1,742	.180	.201
October	2,200	1,300	1,414	.146	.168
November	1,640	1,345	1,490	.154	.172
December	6,550	1,640	2,550	.264	.304
The year	42,600	1,300	7,584	.786	10.617

POTOMAC RIVER (SOUTH BRANCH) NEAR SPRINGFIELD, W. VA.

A gaging station was established at the Baltimore and Ohio Railroad bridge, 3 miles southwest of Springfield, by C. C. Babb, in April, 1894. This station was discontinued in 1896 for want of an observer. On June 26, 1899, a station was established by E. G. Paul at the highway bridge 1½ miles below the original station, near Grace Station. This bridge was carried away by flood in February, 1902. The present station was established August 28, 1903, by E. G. Paul. It is located at the steel highway bridge 2½ miles east of Springfield, W. Va. The bridge has two spans of 150 feet each. During high water the river flows beneath both spans, but at low stages the stream flows beneath the left span only. There is a dam located about 2 miles above the station, and a small island above and also one below. A standard chain gage is located in the center of the left span on the downstream side of the bridge. The length of chain from the end of the weight to the marker is 34.76 feet. Bench mark No. 1 is a nail in a large sycamore tree, 15 feet downstream from the left approach to the bridge. The nail is in the side of the tree away from the river and about 6 feet above the ground. Its elevation is 18.80 feet above gage datum. Bench mark No. 2 is a nail in a large willow tree on the left bank of the river, about 65 feet upstream from the bridge. It is in the side of the tree away from the river and about 2½ feet above the ground. Its elevation is 14.52 feet above gage datum. The initial point for soundings is the river face of the left abutment at the downstream side of the bridge. The channel is straight for several hundred feet above and below the station. Both banks are low and liable to overflow. The bed of the stream is of gravel. The gage is read twice each day by Miss Olivia Blue.

The observations at this station during 1904 have been under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Potomac River (South Branch) near Springfield, W. Va., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
July 9	Hoyt & Hall	143	312	.79	2.50	248
September 9	E. C. Murphy	122	211	.54	2.00	115
September 29	do	108	65	2.05	1.99	[a] 133

[a] Below regular station by wading.

Mean daily gage height, in feet, of Potomac River (South Branch) near Springfield, W. Va., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	a 2.60	2.80	3.75	3.65	5.40	3.45	2.80	2.40	2.00	1.80	1.80	1.80
2	a 2.60	2.80	4.60	4.05	4.85	3.50	2.65	2.50	2.00	1.80	1.80	1.80
3	a 2.60	2.80	4.20	3.95	4.35	3.45	2.60	2.70	2.00	1.80	1.80	1.80
4	a 2.60	2.70	4.35	3.70	4.15	3.40	2.60	2.80	2.00	1.80	1.80	1.90
5	a 2.60	2.60	4.10	3.50	3.90	4.35	2.60	2.80	2.00	1.80	1.80	1.90
6	a 2.60	2.60	3.65	3.35	3.65	4.30	2.50	2.60	2.00	1.85	1.80	1.90
7	a 2.60	3.00	3.45	3.20	3.30	3.90	2.50	2.60	2.00	1.85	1.80	1.90
8	a 2.60	b 6.40	5.55	3.20	3.50	3.80	2.60	2.55	2.00	1.80	1.80	1.90
9	a 2.60	4.85	5.60	3.15	3.40	3.35	2.50	2.50	2.10	1.80	1.80	1.95
10	a 2.60	3.55	4.60	3.20	3.60	3.10	2.85	2.40	2.15	1.80	1.90	2.00
11	a 2.60	3.20	4.05	3.30	3.40	2.95	4.50	2.30	2.10	1.80	1.90	2.00
12	a 2.60	2.70	3.85	3.25	3.25	3.10	3.85	2.25	2.10	1.80	1.90	2.20
13	a 2.60	2.85	3.65	3.20	3.10	3.10	3.50	2.20	2.10	1.80	1.90	2.20
14	a 2.60	2.95	3.50	3.20	3.00	3.00	2.95	2.10	2.20	1.80	1.90	2.20
15	a 2.60	3.05	3.35	3.00	3.00	2.70	2.85	2.10	2.15	1.80	1.90	2.20
16	a 2.60	2.95	3.15	2.85	3.00	2.95	2.55	2.10	2.05	1.80	1.90	2.20
17	a 2.60	2.90	3.10	2.80	3.00	2.85	2.45	2.00	2.00	1.80	1.80	2.20
18	2.60	2.65	3.10	3.00	3.25	3.10	2.50	2.00	2.00	1.80	1.80	2.20
19	2.60	2.95	3.10	3.00	8.05	3.00	2.55	2.00	2.00	1.80	1.80	a 2.10
20	2.60	2.90	3.05	3.00	7.95	5.65	2.60	2.00	1.90	1.80	1.80	2.10
21	2.60	2.95	3.05	3.00	6.30	4.70	2.70	2.00	1.90	1.90	1.80	2.10
22	2.85	3.50	3.40	2.90	5.40	3.95	2.60	2.00	1.90	1.90	1.80	2.10
23	9.05	4.50	3.90	2.80	4.80	3.60	2.80	2.00	1.90	1.90	1.80	2.10
24	5.40	4.05	4.55	2.80	4.30	3.45	2.90	2.00	1.90	1.90	1.80	2.10
25	4.05	3.00	4.45	2.70	3.95	3.20	2.80	2.00	1.80	1.80	1.80	2.20
26	3.45	3.25	4.15	2.80	3.75	2.90	2.50	2.00	1.80	1.80	1.80	2.25
27	3.00	2.95	3.95	3.05	3.80	2.75	2.70	2.00	1.80	1.80	1.80	2.50
28	c 2.90	2.95	3.80	8.60	4.20	2.55	2.60	1.90	1.80	1.80	1.80	2.85
29	2.65	2.95	3.45	8.10	3.65	2.75	2.50	2.10	1.80	1.80	1.80	3.50
30	2.75	.....	3.45	6.60	3.45	2.90	2.40	2.10	1.80	1.80	1.80	3.90
31	c 2.90	.....	3.35	.....	3.45	.....	2.40	2.00	.....	1.80	.....	3.90

a Frozen over. b Ice going out. c Slush ice.

ANTIETAM CREEK NEAR SHARPSBURG, MD.

Antietam Creek rises in the western part of Maryland and flows in a southerly direction, entering the Potomac 10 miles above Harpers Ferry. Its drainage area is mostly of a hilly character and is largely cultivated. This station was established June 24, 1897, by A. P. Davis. It is located a few hundred feet below the bridge on the toll road from Sharpsburg to Keedysville, Md. There is an old dam, not now in use, just below the bridge. The gage is a vertical rod driven into the gravel of the stream bed and spiked to a tree on the left bank near the cable. The bench mark is a copper bolt set in a ledge of rock on the left bank, at a point about 125 feet above the cable. Its elevation is 16.34 feet above gage datum. Discharge measurements are made from a steel-wire cable, which is supported by the forks of sycamore trees on each bank and is anchored to timbers set in the ground. A tagged wire is suspended above the cable. The initial point for soundings is a staple in the tree on the left bank. The channel is straight for 300 feet above

and below the station. It has a width at ordinary stages of about 100 feet; is shallow and unobstructed. There is a good measurable velocity at all stages. The right bank is low and liable to overflow; the left bank is high and rocky, and both are fringed with trees. The bed of the stream is composed of gravel, free from vegetation, and is permanent. There is but one channel at all stages. The gage is read once each day by Charles E. Hammond, the toll gatherer.

The observations at this station during 1904 have been under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Antietam Creek near Sharpsburg, Md., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet*
July 1	Hoyt and Hall	85	154	1.03	1.79	158
July 11	Hoyt and Grover	90	159	.94	1.79	150

Mean daily gage height, in feet, of Antietam Creek near Sharpsburg, Md., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.90	.....	.....	.....	.....	.....	.....	1.60	1.50	1.45	1.50	1.45
2	1.90	.....	.....	.....	.....	.....	.....	1.60	1.50	1.45	1.50	1.45
3	1.75	.....	.....	.....	.....	.....	.....	1.80	1.50	1.40	1.45	1.45
4	2.10	.....	.....	.....	.....	.....	.....	1.65	1.60	1.55	1.50	1.45
5	1.90	.....	.....	.....	.....	.....	.....	1.60	1.55	1.50	1.50	1.40
6	1.90	.....	.....	.....	.....	.....	.....	1.60	1.50	1.45	1.45	1.50
7	1.80	.....	.....	.....	.....	.....	.....	1.60	1.45	1.50	1.40	1.45
8	1.80	.....	.....	.....	.....	.....	.....	1.50	1.55	1.45	1.50	1.45
9	1.80	.....	.....	.....	.....	.....	.....	1.50	1.45	1.45	1.50	1.45
10	1.85	.....	.....	.....	.....	.....	.....	1.50	1.85	1.50	1.50	1.50
11	1.85	.....	.....	.....	.....	.....	.....	3.00	1.60	1.50	1.50	1.55
12	1.90	.....	.....	.....	.....	.....	2.20	1.80	1.55	1.50	1.50	1.40
13	1.85	.....	.....	.....	.....	.....	2.20	1.65	1.50	1.75	1.60	1.60
14	1.85	.....	.....	.....	.....	.....	1.90	1.55	1.65	1.60	1.50	1.50
15	1.70	.....	.....	.....	.....	.....	1.75	1.60	1.65	1.50	1.65	1.45
16	1.70	.....	.....	.....	.....	.....	1.70	1.60	1.80	1.45	1.50	1.55
17	1.70	.....	.....	.....	.....	.....	1.70	1.60	1.60	1.40	1.50	1.55
18	1.80	.....	.....	.....	.....	.....	1.70	1.60	1.50	1.50	1.40	1.55
19	1.80	.....	.....	.....	.....	.....	1.70	1.65	1.40	1.50	1.40	1.55
20	1.80	.....	.....	.....	.....	.....	1.60	1.60	1.65	1.50	1.50	1.60
21	1.85	.....	.....	.....	.....	.....	1.65	1.60	1.60	1.65	1.50	1.65
22	3.90	.....	.....	.....	.....	.....	1.60	1.60	1.60	1.95	1.55	1.65
23	[a]6.00	.....	.....	.....	.....	.....	1.70	1.85	1.55	1.65	1.55	1.55
24	.....	.....	.....	.....	.....	.....	1.75	1.75	1.50	1.60	1.50	1.60
25	.....	.....	.....	.....	.....	.....	1.85	1.60	1.45	1.50	1.55	1.65
26	.....	.....	.....	.....	.....	.....	1.70	1.60	1.50	1.55	1.50	1.75
27	.....	.....	.....	.....	.....	.....	1.60	1.55	1.55	1.50	1.45	1.70
28	.....	.....	.....	.....	.....	.....	1.60	1.45	1.50	1.50	1.35	1.80
29	.....	.....	.....	.....	.....	.....	1.85	1.50	1.50	1.55	1.45	2.15
30	.....	.....	.....	.....	.....	.....	1.70	1.50	1.45	1.45	1.50	2.05
31	.....	.....	.....	.....	.....	.....	1.60	1.50	.....	1.50	.....	1.75

[a] Ice carried gage away; reestablished July 12.

Rating table for Antietam Creek near Sharpsburg, Md., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.35	90	2.30	298	3.30	720	4.30	1,270
1.40	95	2.40	332	3.40	775	4.40	1,325
1.50	108	2.50	367	3.50	830	4.50	1,380
1.60	121	2.60	402	3.60	885	4.60	1,435
1.70	137	2.70	440	3.70	940	4.70	1,490
1.80	155	2.80	482	3.80	995	4.80	1,545
1.90	179	2.90	525	3.90	1,050	5.00	1,655
2.00	206	3.00	570	4.00	1,105	6.00	2,205
2.10	234	3.10	615	4.10	1,160	7.00	2,755
2.20	265	3.20	665	4.20	1,215		

The above table is applicable only for open-channel conditions. It is based upon 12 discharge measurements made during 1898 to 1904, inclusive. It is well defined between gage heights 1.60 feet and 3.50 feet. The table has been extended beyond these limits. Above gage height 3.20 feet the rating curve is a tangent, the difference being 55 per tenth.

Estimated monthly discharge of Antietam Creek near Sharpsburg, Md., for 1904.

[Drainage area, 293 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January 1–23	2,205	137	292	0.997	0.853
July 12–31	265	121	151	.515	.383
August	570	102	137	.468	.540
September	167	95	116	.396	.442
October	193	95	113	.386	.445
November	129	90	107	.365	.407
December	250	95	123	.420	.484

SHENANDOAH RIVER AT MILLVILLE, W. VA.

This station was established April 15, 1895, by C. C. Babb. It is located about one-fourth mile above the Baltimore and Ohio Railroad station at Millville, W. Va. It is best reached by driving from Harpers Ferry, W. Va. The vertical gage is spiked to a large sycamore tree on the left bank a few hundred feet downstream from the cable.

Bench mark No. 1 is a copper plug in the upstream side of the base of the second tree downstream from the gage. Its elevation is 6.68 feet above the zero of the gage. Bench mark No. 2 is the upper surface of the head of a wire nail driven horizontally in a blaze on the base of the first tree upstream from the gage. Its elevation is 7.42 feet above the zero of the gage. Bench mark No. 3 is the upper surface of the head of a wire spike driven in a blaze on the tree to which the gage is fastened on the side away from the river; elevation 9.43 feet. Discharge measurements are made from a three-fourths inch cable from which is suspended a car. The cable, which is suspended over the branches of two large sycamore trees and is securely anchored to the bank at both ends, has a total span of 500 feet. The initial point for soundings is the side of a tree nearest the river at the cable on the left bank. The channel is straight for several hundred feet above and below the station, and the current is swift and unobstructed. Both banks are low, liable to overflow, and are without trees. There is but one channel at all stages. The bed of the stream is composed of mud and rocks. The gage is read once each day by W. R. Nicewarner, the railroad station agent.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Shenandoah River at Millville, W. Va., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
June 13	F. H. Brundage	500	1,771	1.06	1.70	1,883
July 4	Hoyt and Hall	505	1,578	.72	1.20	1,137
July 10	Hoyt and Grover	499	1,561	.88	1.34	1,371
September 28	E. C. Murphy	490	1,147	.49	.50	564
October 20	do	485	1,126	.44	.41	494

Mean daily gage height, in feet, of Shenandoah River at Millville, W. Va., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.80	(a)	(a)	1.80	3.30	4.00	1.50	1.15	0.60	0.45	0.45	0.45
2	.85	(a)	(a)	1.80	3.30	2.60	1.40	1.05	.60	.40	.45	.45
3	1.20	(a)	(a)	1.75	2.70	2.33	1.30	1.10	.60	.40	.40	.50
4	1.20	(a)	(a)	1.70	2.40	2.10	1.20	1.25	.60	.40	.50	.50
5	1.00	(a)	(a)	1.60	2.15	2.60	1.10	1.40	.60	.40	.45	.50
6	1.00	(a)	(a)	1.50	2.10	2.85	1.20	1.40	.60	.40	.45	.55
7	1.10	(a)	(a)	1.50	1.95	4.00	1.15	1.70	.60	.45	.45	.50
8	1.10	(a)	2.30	1.50	2.00	2.90	1.30	1.80	.60	.45	.45	.50
9	1.30	(a)	4.90	1.60	2.00	2.40	1.25	1.45	.55	.40	.40	.50
10	1.20	(a)	3.50	1.70	2.30	2.15	1.35	1.40	.55	.40	.40	.50
11	1.20	(a)	3.00	2.45	2.50	2.00	5.60	1.35	.50	.40	.50	.55

a No observation, gage broken down by ice.

Mean daily gage height, in feet, of Shenandoah River at Millville, W. Va., for 1904—Con.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
12	1.10	(a)	2.50	2.40	2.45	1.85	3.70	1.40	0.50	0.50	0.45	0.50
13	1.10	(a)	2.30	2.20	2.30	1.75	2.80	1.35	.60	.50	.50	.65
14	1.00	(a)	2.00	2.00	2.05	1.50	2.10	1.30	.60	.55	.60	.65
15	1.00	(a)	1.90	1.75	1.90	1.40	1.75	1.10	.90	.50	.60	.75
16	1.00	(a)	1.80	1.65	1.85	1.35	1.50	1.05	.90	.50	.50	.60
17	1.00	(a)	1.75	1.60	1.80	1.40	1.40	1.00	.80	.50	.50	1.65
18	1.00	(a)	1.70	1.55	1.80	1.65	1.30	1.00	.75	.50	.50	1.80
19	1.00	(a)	1.60	1.45	1.90	1.40	1.30	.95	.70	.50	.55	1.55
20	1.10	(a)	1.50	1.45	2.30	1.35	1.20	.90	.65	.45	.50	.80
21	1.30	(a)	1.45	1.30	3.50	1.60	1.20	.90	.60	.60	.50	.70
22	1.60	(a)	1.50	1.25	2.95	1.70	1.20	.85	.65	.60	.50	.70
23	2.30	(a)	1.60	1.20	2.45	1.90	1.15	.90	.60	.60	.50	.70
24	2.60	(a)	1.60	1.15	2.15	1.60	1.10	.80	.55	.55	.50	.70
25	(a)	(a)	1.65	1.10	2.00	1.45	1.20	.90	.50	.50	.50	.80
26	(a)	(a)	1.80	1.10	1.95	1.30	1.30	.80	.50	.50	.45	1.15
27	(a)	(a)	1.85	1.30	2.30	1.20	1.20	.75	.50	.45	.45	1.10
28	(a)	(a)	1.80	2.50	1.95	1.15	1.10	.70	.50	.40	.45	1.30
29	(a)	(a)	1.75	4.30	1.70	1.10	1.10	.60	.50	.40	.45	2.25
30	(a)	.....	1.70	3.85	1.70	1.60	1.25	.55	.45	.40	.45	1.20
31	(a)	.....	1.70	.....	1.55	.....	1.10	.60	.....	.40	.....	1.10

a No observation, gage broken down by ice.

The gage heights were affected by ice conditions during latter half of December.

Rating table for Shenandoah River at Millville, W. Va., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.40	475	1.70	1,865	3.00	4,560	4.30	8,105
.50	540	1.80	2,025	3.10	4,805	4.40	8,415
.60	610	1.90	2,200	3.20	5,055	4.50	8,730
.70	685	2.00	2,395	3.30	5,305	4.60	9,045
.80	765	2.10	2,590	3.40	5,560	4.70	9,360
.90	850	2.20	2,790	3.50	5,820	4.80	9,680
1.00	945	2.30	2,990	3.60	6,085	4.90	10,000
1.10	1,055	2.40	3,200	3.70	6,355	5.00	10,320
1.20	1,170	2.50	3,410	3.80	6,630	6.00	13,520
1.30	1,295	2.60	3,630	3.90	6,910	7.00	16,720
1.40	1,430	2.70	3,860	4.00	7,195	8.00	19,920
1.50	1,570	2.80	4,090	4.10	7,490	9.00	23,120
1.60	1,715	2.90	4,320	4.20	7,795		

The above table is applicable only for open-channel conditions. It is based upon discharge measurements made during 1895 to 1904, inclusive, special weight being given to 1904 measurements. It is fairly well defined between gage heights 0.40 feet and 7 feet. The table has been extended beyond these limits. Above gage height 4.70 feet the rating curve is a tangent, the difference being 320 per tenth.

Estimated monthly discharge of Shenandoah River at Millville, W. Va., for 1904.

[Drainage area, 2,995 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January 1–24	3,630	765	1,251	0.418	0.373
March 8–31	10,000	1,500	2,651	.885	.790
April	8,105	1,055	2,205	.736	.821
May	5,820	1,643	2,916	.974	1.12
June	7,195	1,055	2,463	.822	.917
July	12,240	1,055	1,910	.638	.736
August	2,025	575	1,075	.359	.414
September	850	508	617	.206	.230
October	610	475	519	.173	.199
November	610	475	527	.176	.196
December	2,890	508	892	.298	.344

SHENANDOAH RIVER (SOUTH BRANCH) NEAR FRONT ROYAL, VA.

This station was established June 26, 1899, by A. P. Davis. It is located about 1 mile above the ford, which is near the Norfolk and Western Railroad station. This railroad follows the right bank of the stream. The gage is a vertical timber spiked to a large sycamore tree on the left bank about 800 feet upstream from the cable. Bench mark No. 1 is a headless spike on the river side of an elm tree on the left bank, 8 feet downstream from the gage. It is 1½ feet above ground and has an elevation of 10.49 feet above the zero of the gage. Bench mark No. 2 is nail driven horizontally into the downstream side of the stump of a large sycamore tree 270 feet downstream from the gage. It is 0.5 foot above the ground and is immediately below a blaze. Its elevation is 14.55 feet above the zero of the gage. Discharge measurements are made from a cable, which has a span of 300 feet and is suspended over the branches of two large sycamore trees, with its right end fastened to the tree and its left end anchored in the ground. The initial point for soundings is on the main cable 0.5 foot from the tree on the left bank. The channel is straight for 600 feet above and below the station and the current is sluggish. The river may overflow the right bank, but will not overflow the railroad embankment a few feet back from the river, except at extreme flood stages. The left bank is low, liable to overflow, and is fringed with trees. The bed of the stream is composed partly of rock and partly of sand, and is liable to shift in places. The gage is read twice each day by Miss Brentie Johnson.

Between January 25 and June 30, 1904, the stage of river was observed by means of temporary gages set by the observer, and consequently the record between those dates is approximate.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Shenandoah River (South Branch) near Front Royal, Va., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
June 11	F. H. Brundage	310	846	1.35	4.79	1,140
June 30	Hoyt and Hall	310	936	.97	4.55	906
September 27	E. C. Murphy	274	509	.77	3.50	390
October 19	do	275	516	.64	3.42	331

Mean daily gage, in feet, of Shenandoah River (South Branch) near Front Royal, Va., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	6.44	5.69	4.84	5.19	6.39	4.94	4.50	4.10	3.60	3.40	3.42	3.45
2	6.24	5.59	4.84	5.04	5.84	5.04	4.40	4.05	3.60	3.40	3.40	3.39
3	6.24	5.79	5.04	4.84	5.44	5.29	4.30	4.10	3.60	3.40	3.40	3.50
4	6.54	5.74	4.94	4.69	5.14	6.19	4.20	4.30	3.60	3.40	3.40	[a]3.50
5	6.54	5.74	5.04	4.64	5.09	6.44	4.10	4.40	3.60	3.40	3.42	3.50
6	6.29	5.49	4.99	4.59	4.99	6.49	4.10	4.50	3.65	3.40	3.40	3.45
7	6.19	5.54	5.04	4.59	4.99	5.99	4.05	4.70	3.70	3.40	3.43	3.41
8	6.09	6.34	6.29	4.59	4.99	5.39	4.00	4.45	3.70	3.40	3.45	3.45
9	6.04	6.14	6.39	4.69	5.14	5.04	4.20	4.40	3.70	3.40	3.50	3.45
10	5.94	6.34	6.69	5.24	5.69	4.94	5.50	4.75	3.70	3.40	3.42	3.51
11	5.89	6.34	5.99	5.74	5.84	4.74	7.90	4.60	3.70	3.40	3.40	4.15
12	5.99	6.19	5.74	5.69	5.64	4.69	7.40	4.50	3.70	3.45	3.40	[b]4.40
13	5.99	5.09	5.54	5.34	5.34	4.64	5.40	4.40	3.70	3.55	3.40	4.60
14	6.04	5.99	5.19	5.14	5.24	4.54	4.75	4.20	3.65	3.45	3.55	4.80
15	5.89	5.89	5.09	4.94	4.89	4.49	4.55	4.15	4.20	3.40	3.50	3.95
16	5.74	5.89	4.99	4.84	4.89	4.39	4.40	4.10	3.95	3.40	3.52	4.10
17	5.74	5.84	4.89	4.79	4.89	4.59	4.35	4.00	3.70	3.40	3.50	4.10
18	5.79	5.89	4.89	4.64	5.29	4.64	4.30	4.00	3.60	3.40	3.45	4.20
19	5.89	5.09	4.89	3.54	5.69	4.39	4.35	3.90	3.60	3.40	3.45	3.90
20	5.84	6.24	4.69	4.49	7.59	4.54	4.25	3.80	3.60	3.45	3.40	3.90
21	5.84	6.34	4.69	4.49	6.74	4.99	4.10	3.80	3.50	3.55	3.42	3.70
22	6.39	6.89	4.69	4.39	5.89	5.14	4.10	3.75	3.50	3.50	3.40	3.70
23	8.24	8.39	4.94	4.39	5.44	5.04	4.00	3.65	3.50	3.45	3.43	3.87
24	9.64	8.64	4.94	4.29	5.24	4.74	4.30	3.60	3.50	3.40	3.43	3.95
25	7.24	7.69	4.94	4.39	5.09	4.39	4.40	3.60	3.50	3.40	3.42	3.90
26	6.54	6.14	5.04	4.44	4.99	4.29	4.30	3.55	3.50	3.40	3.40	3.80
27	6.29	6.84	5.09	5.49	4.94	4.34	4.20	3.50	3.40	3.42	3.40	3.95
28	6.14	5.74	5.09	6.24	4.89	4.39	4.35	3.50	3.40	3.40	3.40	3.90
29	5.94	5.19	4.99	6.79	4.89	4.69	4.15	3.50	3.40	3.40	3.40	4.50
30	5.84	.....	5.24	6.64	4.79	4.52	4.20	3.55	3.40	3.40	3.40	4.20
31	5.74	.....	5.29	.....	4.79	.....	4.20	3.60	.....	3.40	.....	4.00

[a] Ice running in river. [b] River frozen entirely across.

Gage heights are approximate from January 25 to March 1.

Rating table for Shenandoah River (South Branch) near Front Royal, Va., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.30	305	4.70	1,045	6.10	2,665	7.50	5,080
3.40	330	4.80	1,130	6.20	2,815	7.60	5,260
3.50	359	4.90	1,220	6.30	2,970	7.70	5,440
3.60	392	5.00	1,315	6.40	3,130	7.80	5,620
3.70	429	5.10	1,420	6.50	3,295	7.90	5,800
3.80	470	5.20	1,530	6.60	3,465	8.00	5,980
3.90	515	5.30	1,640	6.70	3,640	8.20	6,340
4.00	565	5.40	1,755	6.80	3,820	8.40	6,700
4.10	615	5.50	1,870	6.90	4,000	8.60	7,060
4.20	670	5.60	1,990	7.00	4,180	8.80	7,420
4.30	735	5.70	2,115	7.10	4,360	9.00	7,780
4.40	805	5.80	2,245	7.20	4,540	9.50	8,680
4.50	880	5.90	2,380	7.30	4,720	10.00	9,580
4.60	960	6.00	2,520	7.40	4,900		

The above table is applicable only for open-channel conditions. It is based upon seven discharge measurements made during 1900 to 1904, inclusive. It is well defined between gage heights 3.40 feet and 8 feet. The table has been extended beyond these limits. Above gage height 7 feet the rating curve is a tangent, the difference being 180 per tenth.

Estimated monthly discharge of Shenandoah River (South Branch) near Front Royal, Va., for 1904.

[Drainage area, 1,569 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	8,932	2,167	3,031	1.93	2.23
February	7,132	1,410	2,840	1.81	1.95
March	3,623	1,037	1,571	1.00	1.15
April	3,802	728	1,403	.894	.997
May	5,242	1,122	1,802	1.15	1.33
June	3,279	728	1,332	.849	.947
July	5,800	565	1,089	.694	.800
August	1,088	359	614	.391	.451
September	670	330	402	.256	.286
October	376	330	336	.214	.247
November	376	330	339	.216	.241
December	1,130	328	534	.340	.392
The year	8,932	328	1,274	.812	11.02

SHENANDOAH RIVER (NORTH BRANCH) NEAR RIVERTON, VA.

This station was established June 26, 1899, by A. P. Davis. It is located about 2 miles above Riverton, Va., a short distance from the Southern Railway station. It is most easily reached by driving from Front Royal, Va. The vertical gage rod is spiked to timber and to a sycamore tree on the left bank about 100 feet above the cable station. Bench mark No. 1 is a wire nail driven into a pear tree and is located near the fence and 150 feet from the left bank of the river. Its elevation above the zero of the gage is 26.75 feet. Bench mark No. 2 is formed by three wire nails driven flush in the surface of a stump 50 feet downstream from the fence line of the road, at the edge of the field, on the side toward the river. Its elevation is 20.44 feet above the zero of the gage. The original gage was a vertical timber bolted to a large sycamore tree on the right bank. On September 10, 1900, the gage was moved to the left bank and its datum was lowered 1 foot, causing all readings to be increased by 1 foot. The gage at this station washed out in the flood of February 22, 1902, and the station was temporarily abandoned until August 17, 1902, when it was reestablished by E. G. Paul, the zero of the new gage being at the same elevation as the zero of the former gage. Discharge measurements are made by means of a cable, car, and tagged wire just above the ford. The cable has a span of 260 feet, is supported by timbers, and anchored in the ground at each end. The initial point for soundings is 0.5 foot from the timber which supports the tag wire on the left bank. The channel is straight for 600 feet above and below the station. The current has a moderate velocity. Both banks are low and liable to overflow, with a fringe of trees along each bank. The bed of the stream is rocky, permanent, and free from vegetation. There is but one channel at all stages. The gage is read twice each day by L. W. Burke.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Shenandoah River (North Branch) near Riverton, Va., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
June 10	F. H. Brundage	232	417	1.39	4.81	578
July 1	Hoyt and Hall	235	425	1.13	4.71	[a] 480
September 27	E. C. Murphy	234	240	.39	3.95	93
October 19	do	235	292	.45	4.11	130

[a] Average of two measurements.

Mean daily gage height, in feet, of Shenandoah River (North Branch) near Riverton, Va., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	[a] 4.20	.....	.....	4.88	5.85	5.65	4.72	4.30	4.10	4.05	4.00	4.[illegible]
2	[a] 4.20	.....	.....	5.00	5.70	5.05	4.50	4.45	4.05	4.00	4.00	4.[illegible]
3	[a] 4.20	.....	.....	4.98	5.40	4.85	4.38	4.40	4.15	3.95	4.05	4.10
4	[a] 4.20	.....	.....	4.88	5.10	4.80	4.30	4.50	4.15	4.00	4.05	4.10
5	[a] 4.20	.....	[b] 4.70	4.80	5.05	4.85	4.35	4.50	4.10	4.10	4.00	4.10
6	[a] 4.20	.....	4.65	4.72	5.00	6.05	4.35	4.80	4.05	4.10	4.05	4.20
7	[a] 4.20	.....	4.70	4.72	4.90	6.70	4.32	4.50	4.05	4.00	4.05	4.20
8	[a] 4.20	.....	6.20	4.70	4.90	5.30	4.35	4.50	4.10	4.05	4.00	4.[illegible]
9	[a] 4.20	.....	6.20	4.75	4.90	4.95	4.40	4.45	4.05	4.00	4.00	4.10
10	[a] 4.20	.....	5.60	5.10	5.00	4.80	6.15	4.38	4.10	4.00	4.10	4.15
11	[a] 4.20	.....	5.15	5.38	4.95	4.72	6.82	4.40	4.10	4.00	4.10	4.[illegible]
12	[a] 4.20	.....	5.00	5.15	4.90	4.60	6.00	4.35	4.10	4.10	4.05	[d] 4.50
13	[a] 4.20	.....	4.90	5.00	4.90	4.50	5.75	4.35	4.05	4.00	4.10	4.50
14	[a] 4.20	.....	4.80	4.90	4.80	4.50	5.10	4.30	4.20	4.05	4.10	4.50
15	[a] 4.20	.....	4.78	4.80	4.75	4.40	4.85	4.20	4.20	4.00	4.05	4.50
16	[a] 4.20	.....	4.70	4.72	4.80	4.45	4.70	4.30	4.15	4.05	4.10	4.50
17	[a] 4.20	.....	4.70	4.65	4.70	4.45	4.60	4.20	4.15	4.05	4.10	4.50
18	[a] 4.20	.....	4.68	4.55	4.70	4.42	4.55	4.22	4.10	4.05	3.98	4.[illegible]
19	[a] 4.20	.....	4.60	4.58	4.78	4.50	4.50	4.20	4.10	4.00	4.00	4.50
20	[a] 4.20	.....	4.52	4.50	6.45	4.75	4.70	4.22	4.05	4.05	4.00	4.50
21	[a] 4.20	.....	4.56	4.45	5.70	5.25	4.55	4.20	4.25	4.05	4.00	4.50
22	[a] 4.20	.....	4.52	4.48	5.35	5.30	4.40	4.20	4.10	4.00	4.10	4.50
23	[c] 4.20	.....	4.65	4.40	5.15	4.85	4.38	4.30	4.05	4.10	4.10	4.50
24	.....	.....	4.75	4.40	4.95	4.62	4.35	4.35	4.10	4.10	4.10	4.50
25	.....	.....	4.80	4.38	4.78	4.45	4.50	4.20	4.00	4.00	4.02	4.50
26	.....	.....	4.80	4.50	5.15	4.40	4.50	4.25	4.00	4.10	4.00	4.55
27	.....	.....	4.80	4.60	4.95	4.35	4.40	4.20	3.98	4.05	4.05	4.60
28	.....	.....	4.78	6.00	4.80	4.40	4.40	4.20	4.05	4.05	4.00	4.65
29	.....	.....	4.70	7.05	4.70	4.38	4.65	4.10	4.05	4.10	4.05	4.46
30	.....	.....	4.70	6.40	4.60	4.75	4.55	4.10	4.10	4.02	4.10	4.45
31	.....	.....	4.78	.....	4.80	.....	4.45	4.15	.....	4.05	.....	4.35

[a] Frozen up.
[b] The gage was put back March 5, just as it was before, and read from that date.
[c] Ice breaking up.
[d] River frozen Dec. 12 to 25.

MONOCACY RIVER NEAR FREDERICK, MD.

This station was established August 4, 1896, by E. G. Paul, and is located at the county bridge on the toll road leading from Frederick to Mount Pleasant, Md. It is 4 miles northeast of Frederick, about 2,000 feet above the mouth of Israel Creek, and 3,000 feet below the mouth of Tuscarora Creek. The original wire gage has been replaced by a standard chain gage, which is located in the middle of the first span from the right bank and is attached to the bridge floor on the lower side of the bridge. The length of the chain from the end of the weight to the marker is 35.20 feet. The bench mark is a hole drilled in the top of a coping stone on the lower wing of the right abutment, about 100 feet back from the initial point for soundings. Its elevation is 29.17 feet above gage datum. Discharge measurements are made

from the two-span iron highway bridge. The initial point for soundings is a cross cut in the face of the parapet wall on the lower wing of the right abutment. The channel is straight for 300 feet above and 100 feet below the bridge. The bridge has a total span of 310 feet. The channel at this point is divided by a small, low island, which serves as a foundation for the middle pier of the bridge. The right channel is measured from the lower and the left from the upper side of the bridge, as these are better than a continuous section on either side of the bridge. The pier and island obstruct the flow to some extent, causing dead water for 20 feet to the right of the pier at low water and eddies at high water. Both banks are low, liable to overflow, and covered with a fringe of trees, but all water passes beneath the bridge. The bed is composed of gravel and cobblestones, except near the banks, where it is composed of silt and is subject to change. The gage is read twice each day by E. L. Derr.

The observations of this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Monocacy River near Frederick, Md., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
July 12	Hoyt and Grover	172	384	1.24	5.18	475
September 26	N. C. Grover	195	184	0.54	3.71	100
October 20[a]	E. C. Murphy	56	55	1.78	3.67	98

[a] Made above bridge by wading.

Mean daily gage height, in feet, of Monocacy River near Frederick, Md., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.6	4.9	8.1	5.8	4.9	7.4	4.4	4.2	3.8	3.7	3.7	3.7
2	4.9	4.9	7.5	7.2	4.7	6.4	4.3	4.9	3.8	3.7	3.7	3.7
3	4.8	5.4	6.1	6.4	4.7	5.9	4.2	4.7	3.8	3.6	3.7	3.7
4	[a]5.5	4.9	6.2	5.4	4.7	5.3	4.2	4.5	3.8	3.6	3.7	3.7
5	[a]5.1	4.6	5.9	5.4	4.7	7.3	4.1	4.3	3.8	3.5	3.7	3.7
6	[a]4.9	4.6	5.9	5.4	4.7	6.9	4.1	4.0	3.9	3.5	3.7	3.7
7	[a]4.7	8.2	17.0	5.4	4.7	6.8	4.4	4.0	3.9	3.5	3.7	3.7
8	[a]4.6	[b]14.2	[c]17.2	5.6	4.9	5.6	6.1	4.2	3.9	3.5	3.7	3.7
9	[a]4.6	6.4	8.1	7.7	4.9	5.4	7.1	4.5	3.9	3.5	3.7	3.7
10	[a]4.6	6.1	6.5	7.2	5.7	5.1	8.1	4.5	4.9	3.5	3.9	3.9
11	[a]4.6	5.9	6.6	6.3	5.4	5.3	7.2	[d]12.6	5.2	3.5	3.8	4.0
12	[a]4.6	5.4	6.9	5.9	4.7	5.1	6.1	5.6	4.9	3.6	3.8	4.0
13	[a]4.6	5.1	6.2	5.6	4.7	4.9	7.4	4.6	4.8	5.7	3.9	4.0
14	[a]4.6	[a]4.9	5.9	5.3	4.7	4.7	6.4	4.2	4.8	5.2	4.2	4.0
15	[a]4.6	[a]4.9	5.7	5.1	5.0	4.5	5.2	4.2	4.7	4.6	4.1	4.0
16	[a]4.6	[a]4.9	5.6	5.1	4.9	4.5	4.2	4.1	4.7	3.8	4.0	4.0
17	[a]4.5	[a]4.9	5.6	5.0	4.8	4.5	4.1	4.1	4.6	3.7	4.0	4.0

[a] Frozen at gage.
[b] Due to thawing.
[c] Thaw. Maximum gage height, 22.9, due to rain.
[d] Rain.

Mean daily gage height, in feet, of Monocacy River near Frederick, Md., for 1904— Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
18	[a]4.5	[a]4.9	5.5	4.9	4.8	4.5	4.1	4.0	4.6	3.6	3.9	4.0
19	[a]4.5	[a]4.9	5.5	4.8	5.2	4.5	4.1	4.0	4.6	3.6	3.9	4.2
20	[a]4.5	[a]4.9	5.8	4.8	5.1	[b]9.7	4.0	4.2	5.6	3.6	3.9	4.1
21	[a]4.5	[a]4.9	6.1	4.7	4.9	7.3	4.0	4.7	5.2	3.7	3.8	4.0
22	[a]4.5	[c]13.8	6.5	4.6	4.7	5.9	4.0	4.7	4.9	4.8	3.8	4.0
23	[c]19.9	12.2	6.8	4.6	4.6	4.8	4.0	4.6	4.6	4.4	3.8	4.0
24	11.5	9.0	6.1	4.6	4.5	4.5	5.1	4.5	4.4	4.1	3.8	4.2
25	6.1	6.8	5.9	4.6	4.4	4.3	5.1	4.2	3.9	3.9	3.8	4.4
26	5.9	5.1	5.7	4.7	4.4	4.2	5.1	4.2	3.7	3.8	3.8	5.1
27	4.6	4.9	5.6	4.9	4.4	4.1	5.1	4.1	3.9	3.8	3.8	[b]6.5
28	4.6	4.8	5.4	5.3	4.4	4.1	5.0	3.9	4.1	3.7	3.7	9.2
29	5.5	4.8	5.2	5.2	4.3	4.2	4.9	3.8	3.9	3.7	3.7	8.9
30	6.1	.....	5.1	5.1	4.3	4.2	4.4	3.8	3.7	3.7	3.7	7.5
31	5.9	.....	5.4	.....	4.5	.....	4.2	3.8	.....	3.7	.....	5.5

[a] Frozen at gage. [b] Rain. [c] Ice broke.

Rating table for Monocacy River near Frederick, Md., from January 1, 1902, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.50	73	4.90	460	6.60	1,420	14.00	7,340
3.60	86	5.00	500	6.80	1,580	15.00	8,140
3.70	101	5.10	540	7.00	1,740	16.00	8,940
3.80	118	5.20	580	7.20	1,900	17.00	9,740
3.90	137	5.30	630	7.40	2,060	18.00	10,540
4.00	158	5.40	680	7.60	2,220	19.00	11,340
4.10	181	5.50	730	7.80	2,380	20.00	12,140
4.20	207	5.60	780	8.00	2,540	21.00	12,940
4.30	235	5.70	835	8.50	2,940	22.00	13,740
4.40	268	5.80	890	9.00	3,340	23.00	14,540
4.50	303	5.90	945	10.00	4,140	24.00	15,340
4.60	340	6.00	1,000	11.00	4,940	25.00	16,140
4.70	380	6.20	1,120	12.00	5,740		
4.80	420	6.40	1,260	13.00	6,540		

The above table is applicable only for open-channel conditions. It is based upon 26 discharge measurements made during 1896–1904. It is well defined between gage heights 3.65 feet and 10 feet. The table has been extended beyond these limits. Above gage height 6.50 feet the rating curve is a tangent, the difference being 80 per tenth.

Estimated monthly discharge of Monocacy River near Frederick, Md., for 1904.

[Drainage area, 665 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	12,060	305	1,001	1.51	1.74
February	7,460	340	1,409	2.12	2.29
March	9,900	540	1,690	2.54	2.93
April	2,300	340	750	1.13	1.26
May	835	235	405	.609	.702
June	3,900	181	814	1.22	1.36
July	2,620	158	610	.917	1.06
August	6,220	118	447	.672	.775
September	780	101	283	.426	.475
October	835	73	160	.241	.278
November	207	101	122	.183	.204
December	3,500	101	487	.732	.844
The year	12,060	73	682	1.02	13.918

JAMES RIVER DRAINAGE BASIN.

The headwaters of James River lie in the high mountains in the extreme western part of Virginia. It is formed by the confluence of Jackson and Cowpasture rivers in the extreme northern part of Botetourt County, Va., thence it flows easterly across the State and empties into Chesapeake Bay through Hampton Roads.

The river with all of its tributaries lies wholly in Virginia. Its total length is about 335 miles and its total drainage area about 9,700 square miles. The basin is varied in character, changing from the mountainous section in the upper part to low, flat, and often swampy areas as tide water is approached. Jackson and Cowpasture rivers flow from narrow valleys between steep hills over beds of sand and gravel with rock ledges in places, and are bordered with fertile bottom lands. In this portion of the basin the water collects quickly, causing rapid rises in the river below. The James, cutting as it does through the ridges of the mountains, flows alternately across fertile valleys with a gentle current and through breaks in the ridges with rocky and precipitous banks, the fall in these localities being often considerable. It crosses the fall line at Richmond.

Near Cliftonforge and again near Balcony Falls the James flows through ridges of the Alleghenies, with sharp falls over beds of solid rock. At other points similar though less pronounced falls and rapids

occur, as the river cuts through the lesser foothills. Between these mountainous or hilly sections the flow is through broad and fertile valleys over sand and gravelly beds with gentle slope. The fall line is finally crossed at Richmond. A considerable number of dams have been built in the river, generally for diverting water into the old James and Kanawha canal, which followed the river from Richmond to Buchanan, and was at one time utilized throughout that entire distance. The use of this canal has now been abandoned, however, and its right of way is owned and for considerable distances occupied by the Chesapeake and Ohio Railroad. The use of the dams was abandoned with the canal, and in many instances they have not been utilized for power purposes although in good repair.

The principal utilized power on the river is at Richmond. Fluctuations in stage are great. The record of gage height at Cartersville, Va., which extends over a period of five years, shows a range in gage height of nearly 25 feet. The estimated discharge has varied between 75,000 and 500 cubic feet per second.

Prof. D. C. Humphrey made a survey of the river from Richmond to Cliftonforge in 1897, and the profile developed by him was published in Part IV of the Nineteenth Annual Report of the United States Geological Survey, pages 162–173.

Gages were established on James River in 1893 by F. B. Isaacs, engineer for water power of the Chesapeake and Ohio Railway Company, at Ninemile Locks, Columbia, Scottsville, Lynchburg, Balcony Falls, Buchanan, Eagle Mountain, and Cliftonforge. Records of heights of water at these points were made twice daily from 1893 to 1897, and freshet reports were obtained for these years. The gages were not referred to any fixed datum, but the zero of each gage was set at what was considered ordinary low water in the river. During the latter part of 1899 records were resumed, excepting at Scottsville, Balcony Falls, and Eagle Mountain, where the gages have been abandoned.

At Boshers dam, 9 miles above Richmond, is a gage where the height of water is recorded twice daily, showing the supposed head on the crest of dam. This crest, however, is so irregular that the coefficient of discharge has not been ascertained. Another complication exists in the fact that water is deflected into a canal, the quantity not being known.

The United States Weather Bureau maintains river stations in this basin as follows:

James at Lynchburg, Va.
James at Columbia, Va.
James at Richmond, Va.

During 1904 the United States Geological Survey has maintained gaging stations in this basin as follows:

James at Buchanan, Va.
James at Holcomb Rock, Va.
James at Cartersville, Va.
North (of James) at Glasgow, Va.
Appomattox at Mattoax, Va.

JAMES RIVER AT BUCHANAN, VA.

This station was established August 18, 1895, by C. C. Babb. It is located at the iron highway bridge near the Chesapeake and Ohio Railway station, and one-half mile from the Norfolk and Western Railway station. It is about 20 miles above the mouth of North River and one-half mile above the mouth of Purgatory Creek. The United States Weather Bureau maintained a gage at this point for about two years before measurements were made by the Geological Survey. On April 3, 1897, the datum of the original wire gage was lowered 2 feet to avoid negative readings. On November 21, 1903, the wire gage was replaced by a standard chain gage installed by W. C. Sawyer. It is located on the upstream side of the bridge near the center of the left span. The length of the chain from the end of the weight to the marker is 35 feet. Bench mark No. 1 is the top of the upper end of the third floor beam from the left bank. Its elevation is 29.87 feet above gage datum. Bench mark No. 2 is the top of a stone post under the southwest corner of the porch of the Chesapeake and Ohio Railway station. Its elevation is 24.50 feet above gage datum. Bench mark No. 3 is a copper bolt in a ledge of rock on the left bank 500 feet above the station. Its elevation is 16.14 feet above gage datum. This bench mark was established November 21, 1903, at which time the old bench mark on this ledge could not be found. Bench mark No. 4 is the top of the upper end of the seventh floor beam from the left bank. Its elevation is 29.92 feet above gage datum. Discharge measurements are made from the lower side of the two-span iron highway bridge, which has a total span of 350 feet. The initial point for soundings is the end of pin on the lower side of bridge at the left bank. The channel is straight for 800 feet above and for about the same distance below the station. The current has a moderate velocity and is broken by the middle pier of the two-span bridge. Both banks are high, not liable to overflow, and without trees. The bed of the stream is rocky and free from vegetation. The gage is read twice each day by U. H. Hyde.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of James River at Buchanan, Va., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
June 17	R. H. Bolster	320	1,119	1.34	2.98	1,498
August 8	N. C. Grover	323	860	.90	2.32	775
September 17	R. H. Bolster	284	707	.56	1.81	393
September 30	do	284	687	.53	1.74	[a] 364
October 19	do	284	676	.46	1.70	[a] 314

[a] Slight change in bed.

Mean daily gage height, in feet, of James River at Buchanan, Va., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.35	2.71	4.74	3.39	4.72	4.89	3.10	2.42	1.82	1.72	1.75	1.86
2	2.36	2.85	5.44	3.70	4.29	8.02	2.85	2.28	1.80	1.73	1.75	1.86
3	2.28	2.73	4.76	3.71	3.89	8.74	2.71	2.18	1.90	1.73	1.75	1.80
4	2.38	2.42	4.12	3.57	3.79	6.39	2.55	2.10	1.90	1.72	1.75	1.80
5	2.47	2.42	3.32	3.43	3.59	5.38	2.47	2.40	1.90	1.70	1.77	1.80
6	2.43	2.36	3.96	3.27	3.46	4.56	2.45	2.37	1.88	1.70	1.78	1.82
7	2.38	2.62	8.27	3.19	3.39	4.12	2.37	2.29	1.85	1.70	1.77	1.85
8	2.38	4.19	7.20	3.25	3.54	4.04	2.46	2.39	1.80	1.70	1.75	1.85
9	2.33	4.39	6.26	4.47	3.69	3.62	2.31	2.20	1.81	1.70	1.75	1.9
10	2.30	3.69	5.11	4.27	3.59	3.42	2.26	2.20	1.84	1.70	1.75	1.92
11	2.30	3.32	4.48	3.95	3.49	3.34	2.25	2.63	1.85	1.70	1.71	1.93
12	2.28	3.02	4.08	3.77	3.32	3.23	2.49	2.44	1.91	1.70	1.71	1.92
13	2.22	2.82	4.10	3.57	3.16	3.09	2.34	2.25	1.90	1.70	1.75	1.90
14	2.18	2.65	3.86	3.47	3.14	2.93	2.24	2.16	1.85	1.70	1.85	1.90
15	2.08	2.55	3.78	3.33	3.22	2.76	2.19	2.10	1.82	1.70	1.95	1.88
16	1.98	2.47	3.76	3.25	3.34	2.83	2.10	2.00	1.80	1.70	1.90	1.87
17	1.98	2.29	3.54	3.17	3.24	3.00	2.08	2.25	1.80	1.70	1.88	1.85
18	1.98	2.28	3.38	3.06	4.86	3.15	2.01	2.10	1.80	1.70	1.85	1.85
19	1.98	2.55	3.32	2.95	10.12	3.04	2.00	2.20	1.80	1.70	1.83	1.85
20	2.03	2.69	3.22	2.89	7.19	3.17	1.90	2.10	1.80	1.70	1.83	1.85
21	2.13	2.52	3.12	2.79	5.72	3.48	1.90	2.10	1.80	1.75	1.80	1.83
22	2.45	3.22	3.04	2.75	4.86	3.32	1.90	2.10	1.80	1.75	1.80	1.82
23	5.18	5.92	3.32	2.70	4.38	3.01	2.04	2.10	1.78	1.75	1.87	1.82
24	4.78	4.65	4.56	2.65	4.04	2.76	2.19	2.00	1.78	1.75	1.85	1.80
25	3.73	4.32	4.24	2.63	4.04	2.62	2.22	1.97	1.77	1.75	1.88	1.92
26	3.36	3.39	4.04	2.94	4.10	2.54	2.22	1.95	1.77	1.75	1.83	2.12
27	3.10	3.55	3.94	6.40	4.34	2.48	2.20	1.90	1.75	1.75	1.83	2.29
28	2.70	3.33	3.74	8.07	4.32	2.74	2.21	1.90	1.75	1.75	1.83	2.35
29	2.40	3.61	3.57	6.30	3.78	8.42	2.20	1.85	1.75	1.75	1.80	2.42
30	2.39	.....	3.42	5.35	3.54	3.22	2.15	1.85	1.75	1.75	1.80	2.29
31	2.56	.....	3.28	.....	3.64	.....	2.07	1.82	.....	1.75	.....	2.22

Rating table for James River at Buchanan, Va., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.70	330	2.40	861	3.40	2,100	4.40	3,840
1.75	356	2.50	960	3.50	2,250	4.50	4,030
1.80	385	2.60	1,060	3.60	2,410	4.60	4,220
1.85	416	2.70	1,170	3.70	2,570	4.70	4,420
1.90	449	2.80	1,285	3.80	2,740	4.80	4,620
1.95	484	2.90	1,405	3.90	2,910	4.90	4,825
2.00	520	3.00	1,535	4.00	3,090	5.00	5,035
2.10	598	3.10	1,670	4.10	3,270		
2.20	681	3.20	1,810	4.20	3,460		
2.30	768	3.30	1,950	4.30	3,650		

The above table is applicable only for open-channel conditions. It is based upon 5 discharge measurements made during 1904 up to gage height 3 feet. Above 3 feet the curve is based upon three measurements made in 1901 and 1903. It is well defined between gage heights 1.70 and 4 feet.

Measurements above 5 feet gage height are estimated.

Estimated monthly discharge of James River at Buchanan, Va., for 1904.

[Drainage area, 2,058 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	5,413	506	1,164	0.566	0.653
February	7,110	750	1,916	.931	1.00
March	14,010	1,587	3,749	1.82	2.10
April	13,330	1,093	2,937	1.43	1.60
May	20,880	1,726	3,771	1.83	2.11
June	15,640	940	3,143	1.53	1.71
July	1,670	449	762	.370	.427
August	1,093	397	647	.314	.362
September	456	356	397	.193	.215
October	356	330	341	.166	.191
November	484	335	388	.189	.211
December	881	385	484	.235	.271
The year	20,880	330	1,642	.798	10.850

JAMES RIVER AT HOLCOMB ROCK, VA.

This station was established by the Willson Aluminum Company, of Holcomb Rock, Va., in 1899, in connection with measurements to determine the horsepower available at that point. During 1899 the records were fragmentary, but at the commencement of 1900 daily records were taken, which have been furnished to the Geological Survey through the courtesy of George O. Seward, general manager of the company. The gage consists of a copper float 8 by 8 by 8 inches, with a vertical rod 1½ inches square attached to it. The rod, which extends up through the powerhouse floor, is graduated to tenths of a foot. The copper float is inclosed in a 12-inch by 12-inch by 12-foot box, which rests solidly on the bottom of the river. The box is perforated, so that the water in it will always stand at the same level as the water in the river, while the float, being inclosed, is not in danger of being broken by floating timber. The fluctuations of the river are read directly from the rod, which moves up or down with the float as it responds to the variations in the height of the river.

Mean daily gage height, in feet, of James River at Holcomb Rock, Va., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.30	1.75	.....	2.30	4.00	3.80	2.01	1.25	0.95	0.75	0.90	0.70
2	1.40	1.70	.....	2.60	3.70	7.25	1.80	1.40	.95	.25	.70	.75
3	1.10	1.55	.....	2.50	3.15	8.80	1.70	1.30	1.00	1.15	.65	.80
4	1.20	1.50	.....	2.50	2.80	6.70	1.65	1.30	.85	.80	.75	1.05
5	1.65	1.50	.....	2.40	2.65	5.00	1.60	1.30	1.00	.80	.80	1.10
6	1.55	1.55	3.05	2.25	2.50	6.35	1.65	1.30	1.00	.40	.20	1.10
7	1.40	2.25	4.50	2.20	2.35	3.25	1.56	1.30	.90	.85	.95	1.25
8	1.40	3.05	8.95	2.25	2.65	3.25	1.40	1.60	.90	.75	.75	1.20
9	1.40	3.60	6.85	2.55	2.85	2.75	1.40	1.30	.80	.25	.70	1.20
10	1.35	3.05	4.95	3.25	3.15	2.55	1.40	1.40	.90	.75	.75	1.00
11	1.40	2.40	4.05	3.15	2.90	2.35	1.45	1.90	.65	.85	.70	.65
12	1.35	2.10	3.50	2.85	2.65	2.20	1.60	1.90	.95	.85	.80	1.25
13	1.30	2.00	3.30	2.65	2.40	2.10	1.50	1.50	.95	.75	.20	.90
14	1.25	1.85	3.10	2.45	2.30	1.95	1.45	1.20	.95	.75	1.15	.75
15	1.10	1.60	2.85	2.25	2.30	1.75	1.25	1.40	1.00	.80	.85	.75
16	1.20	1.80	2.80	2.25	2.35	1.85	1.30	1.45	1.00	.00	.90	.85
17	.85	1.60	2.65	2.05	2.30	2.10	1.25	1.30	.95	.45	.90	.80
18	1.30	1.45	2.50	2.10	2.50	1.85	1.20	1.50	.75	.70	.80	.80
19	1.15	1.60	2.35	2.05	10.00	1.95	1.00	.90	.90	.60	.80	.80
20	1.15	1.70	2.15	1.95	8.05	1.85	1.20	1.35	.90	.65	.20	.65
21	1.20	1.60	2.20	1.80	5.50	2.60	1.10	1.05	.90	.85	.95	.85
22	1.45	3.20	2.15	1.70	4.30	2.50	1.20	1.30	.80	.95	.75	.90
23	3.75	5.50	2.10	1.70	3.60	2.10	1.30	1.30	.80	1.00	.80	.90
24	3.85	4.35	2.55	1.70	3.10	1.90	1.20	1.15	.80	.70	.80	.90
25	3.20	3.55	3.45	1.60	3.05	1.80	1.40	1.15	.45	.75	.90	.95
26	2.50	3.15	3.10	1.60	3.15	1.60	1.40	1.05	1.10	.70	.80	.95
27	2.20	2.60	2.85	2.65	3.30	1.60	1.25	1.00	.85	.75	.85	.85
28	1.90	.....	2.75	8.75	3.30	2.05	1.30	1.00	.80	.70	.90	1.45
29	1.75	.....	2.55	5.90	2.80	2.10	1.55	1.10	.70	.80	.85	1.35
30	1.75	.....	2.44	4.85	2.50	2.15	1.40	.90	.70	.05	.75	1.30
31	1.65	.....	2.30	.....	2.40	.....	1.00	1.00	.....	.75	.....	1.25

JAMES RIVER AT CARTERSVILLE, VA.

This gaging station was established January 1, 1899, by D. C. Humphreys, and is located at the highway bridge crossing the James between Pemberton and Cartersville, one-half mile from the railroad station at Pemberton and 50 miles above Richmond, Va. The original wire gage was attached to the bridge and referred to a bench mark, the top of the lower end of the fourth floor beam from the right bank, which is 32.04 feet above the zero of the gage. This gage was verified June 23, 1899. The original wire gage was replaced by a standard chain gage installed July 24, 1903, by B. S. Drane. The length of the chain from the end of the weight to the marker is 37.98 feet. Bench mark No. 1 is a standard copper plug set in the capstone of the right abutment at its lower end. It is inclosed by a ring of white paint and is marked by the letters "B.M.U.S.G.S.Hydro." Its elevation is 31.74 feet above gage datum. Bench mark No. 2 is a spot of white paint on the inner eyebar of the lower chord of the bridge, under the pulley end of the gage box. Its elevation is 32.91 feet above gage datum. To provide for readings over 10 feet, two additional markers, respectively 10 and 20 feet below the first, have been placed. The gage is attached to the timbers of the second span from the right bank on the downstream side, at the same height as the hand rail. Discharge measurements are made from the lower side of the bridge to which the gage is attached. The initial point for soundings is the right end of the downstream hand rail. Distances are marked with white paint on the rail. The channel is straight for one-third mile above the station and for 1 mile below. Both banks are high and will overflow only at extreme flood stages. The bed of the stream is composed of rocks and sand and is somewhat shifting. The gage is read once each day by B. W. Palmore, the postmaster.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of James River at Cartersville, Va., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
June 23	R. H. Bolster	688	2,546	1.96	2.84	4,994
September 13	do	639	1,202	1.08	.75	1,301
October 3	do	638	1,169	.96	.70	1,117
October 22	J. C. Hoyt	638	1,265	1.11	.85	1,405

Mean daily gage height, in feet, of James River at Cartersville, Va., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.60	2.10	3.38	3.30	5.90	3.85	2.55	1.45	0.81	0.80	0.65	0.85
2	1.68	2.00	3.30	3.10	5.00	5.20	2.52	1.72	1.00	.75	.75	.88
3	1.60	1.90	4.85	3.10	4.32	7.52	2.10	3.10	.90	.70	.75	.90
4	1.38	1.85	4.85	3.30	3.77	10.00	1.85	2.52	.85	.55	.72	1.00
5	1.35	1.80	4.30	3.28	3.48	7.40	1.70	1.58	.80	.50	.80	1.00
6	1.35	1.88	3.90	3.00	3.22	5.98	1.62	3.37	.70	.55	.72	1.60
7	2.25	3.32	6.08	3.10	3.10	4.92	1.48	2.00	.85	.55	.70	1.70
8	2.55	3.80	13.00	3.05	6.30	4.40	1.85	2.35	.85	.70	.70	1.52
9	1.90	3.50	11.10	3.10	4.92	4.08	1.90	1.70	.80	.65	.70	1.30
10	1.55	4.80	9.18	3.65	5.12	3.60	2.00	1.30	.98	.55	.75	1.38
11	1.45	4.52	6.65	4.55	4.80	3.30	2.55	1.80	1.10	.52	.80	1.28
12	1.47	3.25	5.50	4.10	4.20	2.85	1.52	1.90	.95	.50	.78	1.22
13	1.62	2.90	4.70	3.78	3.75	2.62	1.40	2.12	.78	.50	1.00	1.02
14	1.55	2.75	4.60	3.40	3.42	2.45	1.60	2.00	1.25	.50	1.45	1.10
15	1.50	2.52	4.40	3.20	3.25	2.30	1.48	1.90	3.80	.50	1.32	1.15
16	1.45	2.22	4.00	3.00	3.12	2.18	1.30	1.77	2.43	.68	1.10	1.40
17	1.35	2.20	3.70	2.75	3.02	2.15	1.38	1.40	1.80	.68	1.00	1.38
18	1.40	1.80	3.58	2.58	3.43	2.22	1.40	2.00	.98	.65	.92	2.15
19	1.25	1.90	3.50	2.55	5.13	2.18	1.30	1.95	.98	.55	.95	2.30
20	1.35	2.00	3.20	2.40	10.55	2.15	1.25	1.90	.88	.60	.98	2.22
21	1.45	2.25	3.15	2.30	9.15	2.32	1.10	1.45	.82	.60	.90	[a]2.30
22	1.68	4.60	3.00	2.20	6.15	2.40	1.00	1.23	.95	.82	.85	[a]2.50
23	2.42	6.22	2.90	2.10	5.32	2.85	1.30	1.21	.90	.82	.88	[a]2.30
24	3.00	6.29	2.85	2.08	4.50	2.52	2.08	1.20	.88	.78	.95	1.48
25	5.60	6.15	2.85	2.05	3.98	2.18	2.00	1.28	.82	.75	.90	1.65
26	4.02	4.63	4.30	2.00	3.55	1.88	1.55	1.19	.80	.78	.90	1.90
27	3.48	4.12	4.00	3.00	3.52	1.80	1.62	1.00	.75	.70	.85	1.80
28	3.25	3.95	3.98	6.00	3.50	1.65	2.05	1.00	.68	.62	.85	2.10
29	2.85	3.50	3.65	9.60	3.60	2.00	1.90	.98	.82	.62	.80	2.20
30	1.90	.....	3.30	7.42	3.45	2.35	1.95	.80	.85	.70	.75	1.90
31	2.10	.....	4.00	.....	3.02	.....	1.60	.65	.....	.75	.....	1.75

[a] River frozen.

Rating table for James River at Cartersville, Va., from January 1, 1897, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.50	755	3.20	5,890	5.90	12,170	11.00	28,400
.60	935	3.30	6,100	6.00	12,430	11.20	29,120
.70	1,115	3.40	6,310	6.20	12,970	11.40	29,840
.80	1,295	3.50	6,520	6.40	13,520	11.60	30,560
.90	1,475	3.60	6,740	6.60	14,080	11.80	31,280
1.00	1,660	3.70	6,960	6.80	14,650	12.00	32,000
1.10	1,845	3.80	7,180	7.00	15,230	12.50	33,850
1.20	2,030	3.90	7,400	7.20	15,810	13.00	35,700
1.30	2,215	4.00	7,620	7.40	16,410	13.50	37,600
1.40	2,400	4.10	7,840	7.60	17,010	14.00	39,500
1.50	2,585	4.20	8,060	7.80	17,630	14.50	41,450
1.60	2,770	4.30	8,290	8.00	18,250	15.00	43,400
1.70	2,955	4.40	8,520	8.20	18,890	16.00	47,400
1.80	3,140	4.50	8,750	8.40	19,530	17.00	51,400
1.90	3,330	4.60	8,980	8.60	20,180	18.00	55,400
2.00	3,520	4.70	9,210	8.80	20,840	19.00	59,400
2.10	3,710	4.80	9,440	9.00	21,500	20.00	63,400
2.20	3,900	4.90	9,680	9.20	22,180	21.00	67,400
2.30	4,095	5.00	9,920	9.40	22,860	22.00	71,400
2.40	4,290	5.10	10,160	9.60	23,540	23.00	75,400
2.50	4,485	5.20	10,400	9.80	24,220	24.00	79,400
2.60	4,680	5.30	10,640	10.00	24,900	25.00	83,400
2.70	4,880	5.40	10,890	10.20	25,600	26.00	87,400
2.80	5,080	5.50	11,140	10.40	26,300	27.00	91,400
2.90	5,280	5.60	11,390	10.60	27,000	28.00	95,400
3.00	5,480	5.70	11,650	10.80	27,700	29.00	99,400
3.10	5,680	5.80	11,910				

The above table is applicable only for open-channel conditions. It is based upon 23 discharge measurements made during 1897 to 1904, inclusive. It is well defined between gage heights 0.40 feet and 5 feet. The table has been extended beyond these limits. Above gage height 15 feet the rating curve is a tangent, the difference being 400 per tenth.

Estimated monthly discharge of James River at Cartersville, Va., for 1904.

[Drainage area, 6,230 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	11,390	2,123	3,662	0.587	0.676
February	13,240	3,140	6,200	.995	1.070
March	35,700	5,180	9,786	1.57	1.81
April	23,540	3,520	6,645	1.07	1.19
May	26,825	5,480	9,043	1.45	1.67
June	24,900	2,863	6,785	1.09	1.22
July	4,583	1,660	2,975	.477	.550
August	6,205	1,025	2,918	.468	.540
September	7,180	1,079	1,692	.271	.302
October	1,331	755	1,012	.162	.187
November	2,493	1,025	1,425	.229	.256
December	4,485	1,385	2,755	.442	.510
The year	35,700	755	4,575	.734	9.98

NORTH (OF JAMES) RIVER NEAR GLASGOW, VA.

This river rises on the western slope of the Shenandoah Mountains and flows in a southeasterly direction across the valley between the Shenandoah and Blue Ridge ranges, emptying into James River about 17 miles south of Lexington, Va. Its drainage basin is largely under cultivation, except in the upper part, where it is mountainous and covered with forest growth. This station was established August 21, 1895, by C. C. Babb, assisted by D. C. Humphreys. It is located at the county bridge, three-fourths of a mile from the post-office at Glasgow, Va., and 1 mile above the mouth of North River. The original gage was of the wire type. On July 22, 1903, a vertical rod gage was placed in position. This consists of a 2 by 6 inch rod, nailed to a 3 by 6 inch oak timber, which is sunk to a firm foundation and securely nailed and braced to an overhanging tree on the right bank below the bridge. This gage was established on the same datum as the original wire gage and was read from the bridge. On November 24, 1903, a standard chain gage was established on the lower side of the bridge in the right span. Its datum is the same as that of the wire gage and rod gage, which it replaces. The length of the chain from the marker to the end of the weight is 28 feet. Bench mark No. 1 is a standard copper plug set in the downstream end of the capstone of the right abutment. It is inclosed in a ring of white paint and is marked by the

letters "B. M. U. S. G. S. Hydro." Its elevation is 23.90 feet above gage datum. Bench mark No. 2 is the upper surface of the upper chord over the pulley of the chain gage. Its elevation is 32.28 feet above gage datum. Discharge measurements are made from the lower side of the bridge to which the gage is attached. The initial point for soundings is the center of the end pin of the downstream truss on the left bank. Originally measurements were made from the sidewalk on the upstream side of the bridge, at which point there is a good section. Beginning with 1902, measurements were made from the lower side of the bridge on account of the removal of the sidewalk. The section on the lower side of the bridge is not as favorable for accurate measurements on account of sunken logs and on account of the bridge piers. The channel is straight for 600 feet above and below the station and has a width of 240 feet, broken by two iron piers. Both banks are high, fringed with trees, and not liable to overflow, except at very high water. The bed of the stream is rocky near the right bank and is composed of rocks and mud near the left. The gage is read once each day by B. G. Baldwin.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of North (of James) River near Glasgow, Va.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
June 14	F. H. Brundage	206	648	0.81	1.13	523
September 19	R. H. Bolster	197	504	.34	.45	170
September 30	do	197	512	.35	.49	179
October 19	do	197	506	.31	.46	157

Mean daily gage height, in feet, of North (of James) River near Glasgow, Va., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.90	1.15	1.85	1.55	1.95	2.95	1.00	0.70	0.40	0.50	0.40	0.60
2	.90	1.10	2.05	1.55	1.70	2.75	1.00	.65	.45	.50	.40	.60
3	.90	1.10	1.95	1.45	1.45	3.45	1.85	.70	.50	.35	.40	.60
4	1.20	.90	1.75	1.45	1.35	2.95	1.80	.90	.50	.45	.40	.60
5	1.00	1.00	1.65	1.40	1.30	2.45	1.05	.85	.50	.45	.40	.60
6	.90	1.00	1.65	1.40	1.30	1.95	.90	2.00	.50	.45	.45	.60
7	.85	1.20	1.95	1.35	1.25	1.75	.85	1.15	.50	.45	.50	.70
8	.80	2.60	4.90	1.35	1.80	1.70	.50	.95	.50	.45	.50	.70
9	.75	2.00	3.10	1.95	1.85	1.60	.80	.90	.50	.45	.50	.65
10	.70	1.75	2.55	1.95	1.95	1.45	.85	.90	.50	.40	.50	.60
11	.70	1.65	2.20	1.75	1.85	1.40	1.85	1.90	.50	.45	.50	.60
12	.65	1.60	2.05	1.65	1.75	1.35	1.00	1.15	.50	.45	.50	.60
13	.68	1.50	1.95	1.55	1.70	1.30	.90	1.00	.50	.45	.60	.60
14	.70	1.25	1.85	1.45	1.60	1.15	.85	.95	.50	.45	.70	.55

Mean daily gage height, in feet, of North (of James) River near Glasgow, Va., for 1904—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
15	.95	1.25	1.75	1.35	1.55	1.15	.80	.90	.80	.45	.60	.50
16	.85	1.30	1.65	1.25	1.55	1.15	.70	.80	.65	.45	.60	.50
17	.50	1.30	1.55	1.20	1.45	1.45	.65	.70	.55	.40	.50	.50
18	.65	1.50	1.50	1.15	1.45	1.35	.65	.70	.50	.45	.50	.45
19	.60	1.75	1.45	1.15	4.90	1.30	.70	.75	.45	.45	.55	.40
20	.60	5.30	1.35	1.15	3.30	1.15	.65	.70	.40	.45	.55	.50
21	1.65	6.00	1.35	1.05	2.40	1.05	.65	.70	.40	.45	.60	.50
22	.90	7.50	1.35	1.00	2.10	2.05	.70	.75	.40	.45	.50	.50
23	3.80	7.20	1.35	.95	1.90	1.45	.80	.85	.40	.45	.50	.50
24	2.60	6.40	1.75	.95	1.80	1.05	.80	.75	.40	.40	.50	.50
25	2.10	1.95	1.70	.95	1.70	1.00	.90	.70	.40	.45	.50	.60
26	1.85	1.70	1.55	.95	1.70	1.00	.85	.70	.40	.45	.50	.60
27	1.65	1.55	1.60	2.15	1.60	1.00	.90	.60	.35	.45	.50	.80
28	1.58	1.55	1.60	3.50	1.55	1.35	.80	.55	.35	.45	.50	.90
29	1.50	1.35	1.45	2.90	1.45	1.15	.75	.50	.45	.45	.45	.80
30	1.50	.....	1.60	2.30	1.35	1.05	.75	.50	.40	.45	.60	.75
31	1.25	.....	1.55	.....	1.30	.....	.70	.50	.....	.40	.....	.60

Rating table for North (of James) River near Glasgow, Va., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.35	125	1.10	510	2.50	1,810	3.90	4,120
.40	142	1.20	580	2.60	1,940	4.00	4,320
.45	160	1.30	650	2.70	2,080	4.10	4,530
.50	179	1.40	720	2.80	2,220	4.20	4,740
.55	199	1.50	800	2.90	2,370	4.30	4,960
.60	220	1.60	880	3.00	2,520	4.40	5,180
.65	242	1.70	970	3.10	2,680	4.50	5,410
.70	265	1.80	1,060	3.20	2,840	4.60	5,640
.75	290	1.90	1,150	3.30	3,010	4.70	5,880
.80	320	2.00	1,240	3.40	3,180	4.80	6,120
.85	350	2.10	1,340	3.50	3,360	4.90	6,370
.90	380	2.20	1,450	3.60	3,540	5.00	6,620
.95	410	2.30	1,560	3.70	3,730		
1.00	440	2.40	1,680	3.80	3,920		

The above table is applicable only for open-channel conditions. It is based upon 6 discharge measurements made during 1903 and 1904. It is well defined between gage heights 0.45 feet and 2.00 feet, and from gage height 2.00 to 5.00 feet a fair determination has been computed.

Estimated monthly discharge of North (of James) River near Glasgow, Va., for 1904.

[Drainage area, 831 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	3,920	179	646	0.777	0.896
February	14,310	380	2,555	3.07	3.31
March	6,370	685	1,218	1.47	1.69
April	3,360	410	890	1.07	1.19
May	6,370	615	1,175	1.41	1.63
June	3,270	440	974	1.17	1.31
July	1,105	242	404	.486	.560
August	1,240	179	370	.445	.513
September	320	125	170	.205	.229
October	179	125	158	.190	.219
November	265	142	183	.220	.245
December	380	142	222	.267	.308
The year	14,310	125	747	.898	12.10

APPOMATTOX RIVER AT MATTOAX, VA.

This station was established August 27, 1900, by E. W. Myers. It is located on the two-span deck railroad bridge at Mattoax station, 27 miles southeast of Richmond, on the road to Danville. It is equipped with a standard chain gage, which is attached to the outside of the guard rail of the first span from the right bank. The length of the chain from the end of the weight to the marker is 48.82 feet. A permanent bench mark, consisting of a United States Geological Survey standard iron post, was established August 29, 1903, by B. S. Drane. This post is set at the northwest corner of the Mattoax passenger station, with an elevation of 48.68 feet above gage datum. Bench mark No. 2 is on the outer upstream edge of the top of the upper chord of the upstream truss, opposite the 2-foot mark on the gage scale. Its elevation is 46.60 feet above gage datum. Discharge measurements are made from the downstream side of the railroad bridge to which the gage is attached. The initial point for soundings is the end of the downstream guard rail at the right bank. Distances along this rail are indicated by white paint. The channel is straight for 400 feet above and for 100 feet below the station. The current is moderately swift. The right bank is high and is not subject to overflow. The left bank is high, but overflows beneath the second span of the bridge at high water. The bed of the stream is composed of rock and sand,

and is clean and permanent. There is but one channel at all stages, broken at extreme flood stages by the central pier of the bridge. The sand bottom beneath the second span is subject to change in high water. The gage is read once each day by J. C. Carter.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Appomattox River at Mattoax, Va., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
June 24	R. H. Bolster	66	150	1.37	1.23	205
August 4	N. C. Grover	70	209	1.40	2.01	293
October 4	R. H. Bolster	69	121	1.39	.81	168
October 22	J. C. Hoyt	68	183	1.48	1.72	270

Mean daily gage height, in feet, of Appomattox River at Mattoax, Va., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.70	3.50	4.55	3.75	3.50	1.70	1.50	1.15	0.75	1.15	1.02	1.40
2	2.50	3.65	4.25	3.40	3.00	4.45	1.40	1.50	1.25	1.05	1.07	1.35
3	2.50	2.75	3.65	3.10	2.70	9.05	1.85	1.25	1.35	.90	1.10	1.92
4	2.45	2.70	3.50	2.75	2.50	10.30	1.20	2.30	1.20	.80	1.12	2.92
5	1.65	2.50	3.35	2.55	2.35	5.60	.90	1.30	.85	.80	1.22	2.80
6	1.20	3.10	3.10	2.55	2.25	3.20	.80	1.20	1.35	.83	1.35	6.70
7	1.92	6.25	4.90	2.70	2.25	2.50	.80	1.20	1.10	.85	1.42	7.72
8	2.75	9.00	9.75	3.50	3.50	2.25	.75	.90	.90	.90	1.22	5.73
9	2.60	7.00	11.70	3.55	5.35	2.05	.90	.80	.80	.85	1.22	3.45
10	2.10	5.40	12.60	3.10	4.00	1.95	1.15	3.50	2.00	.83	1.18	2.80
11	2.05	4.50	11.20	2.95	5.75	1.75	1.30	4.80	2.00	.90	1.18	2.45
12	2.30	3.10	4.60	2.55	4.20	1.90	1.05	4.60	.95	.90	1.15	2.06
13	3.15	2.70	4.20	2.45	3.05	1.70	1.02	2.45	.85	.88	1.60	1.45
14	2.35	2.60	3.65	2.30	2.25	1.50	1.10	1.45	.75	.88	3.80	1.82
15	2.25	2.50	4.10	2.25	3.05	1.40	1.15	1.10	14.00	.82	5.65	2.08
16	2.25	2.75	3.75	2.30	6.10	1.35	.85	1.10	15.25	.88	3.20	1.88
17	2.50	4.45	3.60	2.35	3.75	1.40	.80	.95	15.20	.79	2.35	2.50
18	2.20	3.50	3.65	2.25	3.20	1.30	.85	1.00	4.00	.88	2.04	2.20
19	1.85	2.40	3.50	2.10	5.10	1.40	.95	4.80	2.15	.85	1.72	2.62
20	1.50	3.50	3.45	2.10	7.00	1.25	.60	5.70	1.80	.78	1.62	2.40
21	1.85	5.50	3.15	2.05	4.30	1.15	.65	1.70	1.50	1.80	1.63	2.38
22	3.05	8.30	3.55	2.00	3.25	1.15	1.10	1.30	1.35	1.82	1.52	2.40
23	3.50	11.75	3.65	2.00	2.30	1.20	.80	2.70	1.25	1.39	1.63	1.98
24	4.50	12.60	3.45	1.95	2.45	1.25	2.00	1.10	1.15	1.50	1.62	3.62
25	3.80	12.85	3.45	2.00	2.20	1.05	4.80	1.00	1.15	1.10	1.73	6.22
26	3.50	8.00	3.40	2.00	2.00	.95	3.75	.80	1.10	1.05	1.47	6.65
27	3.20	4.60	4.25	2.95	1.85	.90	2.50	.80	1.10	1.12	1.40	5.40
28	3.10	3.85	4.90	9.00	1.75	8.95	2.65	.70	1.05	1.15	1.32	5.35
29	3.00	4.15	4.25	8.40	1.65	4.25	1.80	.70	1.00	1.20	1.33	5.65
30	1.60	.....	3.60	4.45	1.65	3.00	2.00	.80	1.60	1.06	1.38	3.45
31	1.65	.....	3.85	.....	1.50	.....	1.60	.80	.....	1.03	.....	2.70

Rating table for Appomattox River at Mattoax, Va., from August 25, 1900, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.40	140	2.70	496	6.00	1,490	10.60	3,624
.50	150	2.80	519	6.20	1,576	10.80	3,722
.60	160	2.90	542	6.40	1,662	11.00	3,820
.70	170	3.00	565	6.60	1,748	11.50	4,065
.80	180	3.10	590	6.80	1,834	12.00	4,310
.90	190	3.20	615	7.00	1,920	12.50	4,555
1.00	200	3.30	640	7.20	2,012	13.00	4,805
1.10	212	3.40	665	7.40	2,104	13.50	5,055
1.20	224	3.50	690	7.60	2,196	14.00	5,315
1.30	237	3.60	715	7.80	2,288	14.50	5,575
1.40	251	3.70	740	8.00	2,380	15.00	5,845
1.50	265	3.80	765	8.20	2,474	15.50	6,115
1.60	282	3.90	790	8.40	2,568	16.00	6,395
1.70	299	4.00	815	8.60	2,662	17.00	6,965
1.80	316	4.20	875	8.80	2,756	18.00	7,555
1.90	333	4.40	935	9.00	2,850	19.00	8,170
2.00	350	4.60	995	9.20	2,946	20.00	8,815
2.10	370	4.80	1,065	9.40	3,042	21.00	9,490
2.20	390	5.00	1,135	9.60	3,138	22.00	10,200
2.30	410	5.20	1,205	9.80	3,234	23.00	10,930
2.40	430	5.40	1,275	10.00	3,330	24.00	11,700
2.50	450	5.60	1,345	10.20	3,428		
2.60	473	5.80	1,415	10.40	3,526		

The above table is applicable only for open-channel conditions.

Estimated monthly discharge of Appomattox River at Mattoax, Va., for 1904.

[Drainage area, 745 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	965	224	465	0.624	0.719
February	4,730	430	1,369	1.84	1.98
March	4,605	590	1,192	1.60	1.84
April	2,850	342	639	.858	.957
May	1,920	265	665	.893	1.03
June	3,477	190	584	.784	.875
July	1,065	160	283	.380	.438
August	1,380	170	368	.494	.570
September	5,980	175	806	1.08	1.20
October	319	178	206	.277	.319
November	1,362	202	325	.436	.487
December	2,251	248	732	.983	1.13
The year	5,980	160	636	.854	11.545

ROANOKE RIVER DRAINAGE BASIN.

Roanoke River proper is formed by the confluence of Dan and Staunton rivers at Clarksville, Mecklenburg County, Va., 185 miles above the mouth of the stream, though the name "Roanoke" is also applied to the upper waters of Staunton River. These streams drain, respectively, 3,798 and 3,546 square miles. Staunton River is the more northerly of the two, its drainage basin lying entirely in Virginia. It rises among the eastern foothills of the Blue Ridge southwest of Roanoke and Salem, being known in this part of its course as the Roanoke, and flows at first northeast, then southeast through Montgomery, Roanoke, Bedford, Campbell, Halifax, and Mecklenburg counties to the junction with the Dan.

A large part of the area drained by the Dan lies in North Carolina. The stream rises in Surry County, N. C., and in Patrick County, Va., and flows at first southeast through Stokes County, N. C., then northeast through Rockingham and Caswell counties, N. C., and through Pittsylvania, Halifax, and Mecklenburg counties, Va., to the junction with the Staunton.

Roanoke River drains a total area of about 9,200 square miles and empties into Albemarle Sound a short distance below Plymouth, N. C.

It is navigable at all stages for 120 miles to Weldon, N. C., where the river crosses the fall line.

The rainfall on the basin above the fall line is about 48 inches per annum and is evenly distributed throughout the year. The average amount probably increases slightly as the stream is ascended, though the records of rainfall over the basin are too incomplete to decide this matter. The slopes in the headwaters and in the upper tributaries are steep, freshets on the river are violent, and the fluctuations of height occur with great rapidity. Rises of 50 feet and over have been noted at Weldon, and freshets in which the rate of rise is 10 feet a day or more are frequent.

The United States Weather Bureau maintains gages on Roanoke River at Clarksville, Va., and Weldon, N. C., and on Dan River at Danville, Va. Gaging stations were maintained by the United States Geological Survey during 1904 as follows: Roanoke (upper portion of Staunton) at Roanoke, Va.; Staunton at Randolph, Va.; Banister at Houston, Va.; Dan at South Boston, Va.; Dan at Madison, N. C., and Mayo at Madison, N. C.

ROANOKE RIVER AT ROANOKE, VA.

This station was established July 10, 1896, by D. C. Humphreys. The original gage of the wire type was replaced November 28, 1903, by a standard chain gage installed by W. C. Sawyer. The datum is the same as that of the gage which it replaced. The length of the chain from the end of the weight to the marker is 27.50 feet. Bench mark No. 1 is the downstream upper edge of the second floor beam from the left abutment. Its elevation is 21.98 feet above gage datum. Bench mark No. 2 is a standard copper bolt set in the face of the lower wing wall of the left abutment, about 4 feet above the ground. Its elevation is 19.70 feet above gage datum. Discharge measurements were made from the Walnut Street Bridge, at which the gage is located, up to July 21, 1903. Since that time they have been made from the Jefferson Street Bridge, at which the section is more suitable. The initial point for soundings is the left end of the downstream hand rail. The channel is nearly straight and has a width of 160 feet between abutments, broken by one pier. The current is rapid. The bed of the stream is composed of coarse gravel and small bowlders. The right bank is above high water, but the left is liable to overflow at extreme flood stages. The gage is read once daily by Richard P. Royer.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Roanoke River at Roanoke, Va., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
June 20	F. H. Brundage	111	269	1.09	1.32	294
August 8	N. C. Grover	113	345	1.37	1.67	473
September 16	R. H. Bolster	108	214	.59	.80	129
September 29	do	106	186	.49	.68	93
October 18	do	105	170	.44	.63	76

Mean daily gage height, in feet, of Roanoke River at Roanoke, Va., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.95	0.75	1.75	1.15	1.05	2.45	2.10	1.50	0.85	0.65	0.65	0.70
2	.90	.75	1.80	1.10	1.05	3.25	1.50	1.70	1.20	.65	.65	.70
3	.80	.80	1.65	1.05	1.05	1.95	1.20	1.40	1.30	.60	.65	.75
4	.30	.95	1.55	1.05	1.05	1.45	1.00	1.50	.95	.60	.65	.80
5	1.05	.70	1.45	1.05	1.05	1.55	1.10	1.60	.95	.65	.75	.80
6	.65	.95	1.35	1.00	1.10	1.35	1.00	2.60	.90	.60	.70	1.00
7	.80	1.15	2.55	1.00	1.10	1.25	1.00	1.65	.85	.60	.75	1.00
8	.80	1.80	2.75	1.10	1.20	1.35	1.00	1.70	.80	.65	.75	.90
9	.80	1.40	2.06	1.15	1.20	1.15	.95	2.00	.80	.65	.75	.80
10	.80	1.25	1.80	1.15	1.30	2.05	1.50	3.00	.80	.65	.70	.80
11	.90	1.10	1.65	1.10	1.25	1.55	1.20	3.60	.75	.65	.70	.75
12	.90	1.10	1.45	1.25	1.15	1.75	1.10	2.40	.80	.65	.70	.70
13	.80	1.05	1.45	1.20	1.10	1.45	.95	1.60	.80	.65	.75	.70
14	.80	1.10	1.40	1.10	1.05	1.35	.90	1.40	.80	.65	.90	.70
15	.30	.95	1.40	1.15	1.15	1.20	.80	1.40	.90	.60	.85	.70
16	.85	.85	1.30	1.05	1.10	1.30	.80	1.40	.85	.65	.75	.70
17	.85	1.05	1.25	1.05	1.05	1.55	.70	1.15	.75	.65	.80	.75
18	.60	.90	1.20	.95	1.10	1.45	.70	1.15	.75	.65	.80	.75
19	1.35	.95	1.20	1.05	2.35	1.25	.70	1.10	.75	.65	.75	.70
20	.60	1.10	1.15	1.05	1.95	1.40	.70	1.15	.75	.65	.75	.65
21	.80	.95	1.15	.90	1.65	1.60	.70	1.00	.75	.65	.75	.65
22	.85	1.10	1.10	.85	1.45	1.40	.70	1.00	.75	.65	.75	.65
23	1.45	1.80	1.10	1.05	1.35	1.20	1.00	1.00	.70	.65	.75	.65
24	1.25	1.50	1.25	.75	1.25	1.10	1.20	.95	.70	.65	.75	.70
25	1.05	1.30	1.25	.85	1.25	1.00	.95	.95	.70	.65	.75	.70
26	1.05	1.25	1.25	.95	1.55	1.00	1.70	.90	.70	.65	.70	.80
27	.90	1.15	1.25	.95	1.35	1.40	1.30	.90	.70	.65	.70	.90
28	.85	1.10	1.25	1.45	1.25	1.40	2.75	.85	.70	.70	.70	.90
29	.95	1.35	1.20	1.15	1.05	1.20	1.50	.90	.70	.65	.70	.80
30	.85	.....	1.15	1.15	1.05	1.20	1.30	.85	.70	.65	.70	.70
31	.75	.....	1.15	.....	1.65	.....	1.20	.85	.....	.65	.....	.70

Rating table for Roanoke River at Roanoke, Va., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.30	43	0.95	167	2.20	850	4.00	2,905
.35	47	1.00	181	2.30	940	4.20	3,175
.40	52	1.10	212	2.40	1,030	4.40	3,445
.45	58	1.20	247	2.50	1,130	4.60	3,715
.50	65	1.30	286	2.60	1,230	4.80	3,985
.55	73	1.40	330	2.70	1,330	5.00	4,255
.60	82	1.50	380	2.80	1,435	5.20	4,525
.65	92	1.60	430	2.90	1,545	5.40	4,795
.70	103	1.70	490	3.00	1,660	5.60	5,065
.75	115	1.80	550	3.20	1,900	5.80	5,335
.80	127	1.90	620	3.40	2,140	6.00	5,605
.85	140	2.00	690	3.60	2,390	7.00	6,955
.90	153	2.10	770	3.80	2,645	8.00	8,305

The above table is applicable only for open-channel conditions. It is based upon discharge measurements made during 1896 to 1904. It is well defined between gage heights 0.60 feet and 7 feet. The table has been extended beyond these limits. Above gage height 4 feet the rating curve is a tangent, the difference being 135 per tenth.

Estimated monthly discharge of Roanoke River at Roanoke, Va., for 1904.

[Drainage area, 388 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	355	43	150	0.387	0.446
February	550	103	229	.590	.636
March	1,380	212	395	1.02	1.18
April	355	115	202	.521	.581
May	985	196	292	.753	.868
June	1,960	181	417	1.07	1.19
July	1,380	103	264	.680	.784
August	2,390	140	453	1.17	1.35
September	286	103	133	.343	.383
October	103	82	91	.235	.271
November	153	92	111	.286	.319
December	181	92	118	.304	.350
The year	2,390	43	238	.613	8.358

STAUNTON RIVER AT RANDOLPH, VA.

This station was originally established August 27, 1900, by E. W. Myers, and is located on the railroad bridge about five-eighths of a mile southwest of the Southern Railway station at Randolph, Va. The present gage was installed by B. S. Drane, May 20, 1903. It is a standard chain gage, and occupies practically the same position as the wire gage which it replaced. It is attached to the upstream guard rail in the middle of the second span from the left bank. The datum is the same as that of the original gage. The length of the chain from the end of the weight to the marker is 43.13 feet. Bench mark No. 1 is the top of the floor beam nearest the zero of the gage scale, at a point 0.2 foot downstream from the adjacent tie. Its elevation is 42.01 feet above the gage datum. Bench mark No. 2 is a copper bolt set in the capstone on the downstream side of the left abutment, about 3 feet from the end of the ties. Its elevation is 37.01 feet above gage datum. Discharge measurements are made from the bridge to which the gage is attached. The current is moderately rapid and has a well-distributed velocity. The channel is straight for a considerable distance above and below the station, and has a width at ordinary stages of above 400 feet, broken by one bridge pier. The bed is composed mainly of firm material, and is permanent. The bridge makes a small angle with the normal to the direction of the current. The gage is read once daily by J. E. Figg, the station agent.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Staunton River at Randolph, Va., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
June 22	F. H. Brundage	233	865	2.37	4.47	2,049
September 27	R. H. Bolster	220	468	1.68	2.70	787
October 22	do	224	517	1.59	2.92	822

Mean daily gage height, in feet, of Staunton River at Randolph, Va., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.5	3.9	5.4	4.5	4.9	11.8	6.2	5.9	4.6	2.7	2.9	3.4
2	4.6	4.2	5.2	4.4	5.1	12.2	5.8	6.0	4.8	2.8	2.8	3.7
3	4.5	4.4	5.0	4.3	5.0	8.6	5.6	6.2	4.9	2.9	2.7	3.9
4	4.4	4.8	5.1	4.4	5.2	6.9	5.4	6.4	4.7	3.0	2.8	3.8
5	4.5	5.2	5.2	4.5	5.1	5.6	4.2	7.9	4.5	2.9	2.9	3.7
6	4.6	7.1	5.0	4.6	5.1	5.4	4.3	8.2	4.6	3.1	3.0	3.8
7	4.4	7.4	5.4	4.5	5.4	5.2	3.9	6.8	4.4	2.9	3.1	3.9
8	4.2	7.2	5.6	4.4	5.6	5.1	3.6	5.5	4.2	2.8	3.0	3.9
9	4.0	6.9	5.9	4.3	5.8	4.9	3.5	6.6	3.9	2.7	3.2	4.2

Main daily gage height, in feet, of Staunton River at Randolph, Va., for 1904—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
10	4.1	6.6	6.1	4.4	6.0	5.0	3.6	9.4	4.0	2.9	3.6	4.1
11	4.3	6.2	6.2	4.4	6.2	4.8	3.4	9.2	4.1	2.8	3.9	4.2
12	4.5	5.6	6.4	4.5	5.8	4.9	3.5	5.6	4.6	2.7	4.3	4.4
13	4.4	5.1	6.2	4.4	5.4	5.2	3.6	4.5	5.8	2.6	4.9	4.8
14	4.7	4.6	5.9	4.5	4.9	4.7	3.7	4.2	6.4	2.7	4.7	4.5
15	4.8	4.8	5.7	4.7	4.3	4.9	3.8	3.9	6.1	2.6	4.6	4.6
16	4.9	5.1	5.6	4.8	5.7	5.1	3.6	3.6	5.4	2.7	4.3	4.4
17	4.6	5.3	5.5	4.6	6.9	5.3	3.5	3.5	4.2	2.6	3.7	4.2
18	4.4	6.1	5.2	4.4	8.4	5.0	3.3	3.7	4.1	2.5	3.3	4.1
19	4.2	6.8	5.0	4.3	7.2	5.1	3.1	3.9	3.8	2.6	3.1	3.8
20	3.8	7.4	4.8	4.1	6.5	5.3	3.2	4.1	3.6	2.7	3.2	3.7
21	4.2	8.2	5.0	4.0	5.6	5.5	3.0	4.2	3.7	3.4	3.3	3.9
22	4.8	10.4	5.3	3.9	5.4	5.2	2.8	4.4	3.4	2.9	3.2	4.3
23	5.3	9.6	5.6	3.8	5.5	5.2	2.7	4.3	3.1	2.8	3.1	4.8
24	5.4	8.2	5.4	3.9	5.3	5.4	3.3	4.5	3.0	2.7	2.9	5.2
25	5.2	6.8	5.1	3.8	4.9	5.3	3.9	4.6	2.8	2.7	3.0	5.1
26	4.9	6.2	4.9	5.9	4.6	5.5	5.8	4.8	2.9	2.8	3.1	4.9
27	4.6	5.8	4.7	7.1	4.4	5.7	7.6	4.5	2.7	2.9	3.0	4.7
28	4.3	5.4	4.5	6.9	4.2	5.8	8.1	4.7	2.9	2.8	3.2	4.5
29	4.0	5.3	4.6	5.7	4.0	6.7	7.2	4.9	2.8	2.7	3.1	4.2
30	3.9	.....	4.5	4.8	3.8	6.4	6.7	5.2	2.8	2.8	3.3	4.3
31	3.8	.....	4.4	.....	6.9	.....	5.8	5.1	.....	2.7	.....	3.9

Rating table for Staunton River at Randolph, Va., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.50	590	3.90	1,620	5.30	2,775	7.40	4,720
2.60	655	4.00	1,700	5.40	2,860	7.60	4,920
2.70	725	4.10	1,780	5.50	2,950	7.80	5,120
2.80	795	4.20	1,860	5.60	3,040	8.00	5,320
2.90	865	4.30	1,940	5.70	3,130	8.50	5,820
3.00	935	4.40	2,020	5.80	3,220	9.00	6,340
3.10	1,005	4.50	2,100	5.90	3,310	9.50	6,865
3.20	1,080	4.60	2,180	6.00	3,400	10.00	7,390
3.30	1,155	4.70	2,265	6.20	3,580	10.50	7,915
3.40	1,230	4.80	2,350	6.40	3,770	11.00	8,440
3.50	1,305	4.90	2,435	6.60	3,960	11.50	8,980
3.60	1,380	5.00	2,520	6.80	4,150	12.00	9,530
3.70	1,460	5.10	2,605	7.00	4,340		
3.80	1,540	5.20	2,690	7.20	4,530		

The above table is applicable only for open-channel conditions. It is based upon 14 discharge measurements made during 1902 to 1904, inclusive. It is well defined between gage heights 2.70 feet and 4.60 feet. The table has been extended beyond these limits. Above gage height 4.60 feet the rating curve is probably accurate to within 10 per cent.

Estimated monthly discharge of Staunton River at Randolph, Va., for 1904.

[Drainage area, 3,076 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	2,860	1,540	2,087	0.678	0.782
February	7,810	1,620	3,667	1.19	1.28
March	3,770	2,020	2,787	.906	1.04
April	4,435	1,540	2,224	.723	.807
May	5,720	1,540	2,939	.955	1.10
June	9,750	2,265	3,397	1.10	1.23
July	5,420	725	2,117	.688	.793
August	6,760	1,305	2,899	.942	1.09
September	3,770	725	1,801	.586	.654
October	1,230	590	787	.256	.295
November	2,435	725	889	.289	.322
December	2,690	1,230	1,881	.612	.706
The year	9,750	590	2,290	.744	10.10

DAN RIVER AT MADISON, N. C.

This station was established May 14, 1903, by E. W. Myers. It is located at the Southern Railway bridge about one-fourth mile from Madison and one-half mile above the mouth of Mayo River. The standard chain gage is located on the upstream side of the bridge in the sixth panel of the first span from the left end. The length of the chain from the end of the weight to the marker is 35.24 feet. Bench mark No. 1 is the edge of the top of a large wire nail driven flush into the top corner of the wooden floor beam beneath the gage box on the upstream side of the bridge. The point is indicated by the letters "B. M." in white paint. When the gage reads zero, the water surface is 34.10 feet below this bench mark. Bench mark No. 2 is a standard iron bench-mark post set in cleared level ground on the left or south side of the railway track. It is 77 feet west of the initial point for soundings, and 9 feet south of the south rail of the track. Its elevation above the water surface when the gage reads zero is 36.21 feet. Discharge measurements are made from the upstream side of the covered wooden two-span railway bridge and its wooden approaches. The initial point for soundings is the end of the guard rail of the trestle over the left bank. Distances are measured along the upstream guard rail and are marked with white paint. Above the station the channel is straight for about 600 feet and the velocity of

the current is good. About 300 feet below the station the channel makes an abrupt turn. The right bank is low and overflows. There is a long trestle approach to the bridge on this side, and all water passes beneath the bridge and approaches. The left bank is low and overflows.

There is a small stream entering from this side. The bed of the stream is sandy and probably permanent. There is but one channel at all stages. The gage is read once each day by B. F. Reynolds.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrograper.

Discharge measurements of Dan River at Madison, N. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
January 23	B. S. Drane	151	405	1.90	2.18	772
March 10	do	151	321	1.97	1.80	631
Do	do	151	318	1.96	1.79	623
April 15	do	149	224	1.83	1.06	411
April 16	do	149	224	1.84	1.09	412
June 6	do	150	196	1.81	.90	356
Do	do	150	198	1.82	.90	361
June 7	do	152	344	1.98	1.90	682
September 26	do	148	159	1.59	.50	254
September 27	do	148	159	1.59	.52	254
December 19	do	148	150	1.85	.58	278
December 20	do	148	159	1.98	.65	314

Mean daily gage height, in feet, of Dan River at Madison, N. C., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.90	1.00	1.50	1.65	1.00	2.40	1.80	1.20	1.50	0.35	0.30	0.50
2	.95	.55	1.50	1.55	1.00	2.70	1.20	3.80	1.85	.30	.30	.45
3	1.00	.95	1.45	1.40	1.00	1.90	.85	3.25	1.50	.30	.30	1.45
4	.60	.80	1.40	1.30	1.00	1.45	.75	1.85	1.20	.30	.35	1.10
5	.55	.80	1.35	1.25	.90	1.10	.70	1.00	1.40	.30	.80	.75
6	.65	1.35	1.20	1.20	.90	.90	.90	2.20	1.10	.30	.70	2.50
7	1.00	1.60	1.40	1.40	.90	2.30	1.00	5.40	.80	.30	.40	1.50
8	1.00	4.05	4.80	1.60	2.00	1.20	.80	3.60	.80	.25	.40	1.20
9	.85	2.35	2.45	1.50	1.55	1.10	.70	2.20	.80	.20	.40	.80
10	.90	1.60	1.90	1.60	1.80	.80	.75	5.20	.70	.20	.40	.75
11	1.10	1.20	1.70	1.30	1.35	4.00	1.00	2.80	1.00	.20	.35	.65
12	1.00	1.20	1.55	1.25	1.10	3.10	1.10	2.20	.80	.20	.30	.60
13	1.10	1.10	1.40	1.10	1.00	2.00	1.35	1.60	.60	.20	.50	.55
14	1.00	1.25	1.45	1.15	.90	1.30	.90	1.20	1.00	.20	.50	.50
15	.75	1.30	1.60	1.10	1.60	1.10	.50	1.10	1.00	.20	.55	.50
16	.70	1.20	1.35	1.15	1.10	.90	.40	3.70	1.20	.20	.60	.50
17	.90	.80	1.10	1.10	.90	2.20	.55	1.85	1.10	.20	.55	.70
18	.75	.90	1.25	1.00	7.30	1.80	.50	1.30	1.10	.20	.50	.70

Mean daily gage height, in feet, of Dan River at Madison, N. C., for 1904—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
19	.65	1.20	1.40	1.00	3.10	3.70	.40	1.00	1.00	.20	.50	.60
20	.70	2.65	1.20	1.00	1.80	1.50	.45	4.00	.50	.25	.50	.60
21	1.15	1.75	1.20	.90	1.40	1.30	.50	5.90	.50	.30	.50	.60
22	1.05	5.50	1.30	.90	1.25	2.20	2.70	2.45	.50	.30	.45	.60
23	2.05	4.05	1.25	.85	1.10	1.25	1.90	1.65	.50	.30	.50	.50
24	1.50	2.80	10.30	.80	1.00	.90	2.70	1.50	.50	.30	.45	.85
25	1.25	2.05	3.90	.90	1.05	.80	1.50	1.35	.40	.30	.45	.95
26	1.10	1.65	2.50	1.00	1.00	.70	1.00	1.20	.40	.30	.40	1.00
27	1.00	1.60	2.50	2.00	.90	.60	1.20	1.10	.40	.30	.40	1.30
28	.75	1.50	2.70	1.90	.90	.90	1.40	1.00	.40	.30	.40	2.65
29	.35	1.50	2.10	1.35	.80	3.90	3.00	.90	.40	.30	.45	1.95
30	1.15	.....	1.80	1.20	.80	2.40	2.30	.90	.40	.30	.50	1.40
31	1.05	.....	1.60	.....	.80	.....	3.50	.80	.....	.30	.....	1.10

Rating table for Dan River at Madison, N. C., from May 7, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.20	180	0.60	278	1.00	386	1.80	642
.25	192	.65	291	1.10	416	1.90	676
.30	204	.70	304	1.20	446	2.00	710
.35	216	.75	317	1.30	476	2.10	744
.40	228	.80	330	1.40	508	2.20	778
.45	240	.85	344	1.50	540	2.30	813
.50	252	.90	358	1.60	574	2.40	849
.55	265	.95	372	1.70	608	2.50	885

The above table is applicable only for open-channel conditions. It is based upon 10 discharge measurements made during 1904 and 4 measurements made during 1903. It is well defined between gage heights 0.50 foot and 2.50 feet.

Discharge estimated above 2.50 gage height.

Estimated monthly discharge of Dan River at Madison, N. C., for 1903–4.

Month	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
1903.			
May 8–31	2,465	574	992
June	3,300	710	1,199
July	2,735	416	742
August	4,250	401	910
September	2,495	358	541
October	813	330	398
November	1,020	317	418
December	795	265	388

Estimated monthly discharge of Dan River at Madison, N. C., for 1903–4—Continued.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
1904.			
January	727	216	376
February	2,375	265	659
March	5,255	416	808
April	710	330	463
May	3,455	330	550
June	1,575	278	653
July	1,335	228	480
August	2,615	330	865
September	659	228	349
October	216	180	195
November	330	204	242
December	953	240	386
The year	5,255	180	502

DAN RIVER AT SOUTH BOSTON, VA.

This station, which was established on August 27, 1900, by E. W. Myers, is in the town of South Boston, Va., on the railroad bridge of the Norfolk and Western Railroad which crosses the river at that place. On May 18, 1903, B. S. Drane replaced the wire gage with a standard chain gage. The datum was not changed. The gage is located on the downstream guard rail near the center of the first span from the left bank. The length of the chain from the end of the weight to the marker is 35.02 feet. Bench mark No. 1 is the sharp inner corner toward the left bank of the plate attached to the inner surface of the struts at the center of the left span and to the bearing of the wooden floor beam and tie. The elevation of the top of the plate is 32.86 feet above gage datum. Bench mark No. 2 is the top of a standard copper bolt set in the capstone of the abutment of the viaduct by means of which the Southern Railway crosses the highway a short distance upstream from the Norfolk and Western and Southern Railway crossing. Its elevation is 30.65 feet above gage datum.

Discharge measurements are made from the bridge to which the gage is attached. The initial point for soundings is the left end of the downstream guard rail. This is a very good station for the gaging of all except the very highest stages of flow. At extreme heights the river spreads out over a flood plain of considerable width. The trestle connecting the bridge with the embankment on the south side of the river is on a curve of rather high degree. The bed of the stream is of

coarse sand and probably shifts only slightly. The gage is read twice daily by J. Mercer East.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Dan River at South Boston, Va., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
June 21	F. H. Brundage	253	1,542	1.57	2.68	2,422
September 15	R. H. Bolster	295	3,820	2.85	10.82	10,890
September 28	do	243	1,152	1.20	1.22	1,385
October 20	J. C. Hoyt	238	1,015	.89	.745	904

Mean daily gage height, in feet, of Dan River at South Boston, Va., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.95	2.15	2.40	2.25	2.30	3.20	3.10	4.67	1.25	1.28	0.35	1.55
2	1.85	1.80	2.20	2.25	1.80	4.99	2.90	4.60	2.37	.72	.68	1.48
3	2.10	2.05	2.15	2.20	1.40	5.45	2.47	5.00	4.75	.20	.98	1.55
4	1.75	1.90	2.30	2.00	1.70	3.55	1.95	3.77	4.02	.42	1.02	2.07
5	1.62	2.10	2.25	1.75	1.45	2.45	1.35	2.00	2.79	.47	1.02	2.58
6	a.55	2.25	2.35	1.65	1.40	1.80	.92	1.67	2.10	.95	.72	3.18
7	.62	2.20	3.50	1.75	1.90	2.65	.87	1.57	1.30	.67	.42	4.62
8	1.45	6.10	4.55	1.80	1.80	3.15	1.57	4.80	.95	.37	.68	3.68
9	2.07	6.05	4.95	1.70	1.65	2.55	1.05	7.25	1.72	.15	1.12	2.70
10	1.90	3.80	4.20	1.90	1.80	1.95	.92	11.15	1.32	.02	1.18	1.92
11	2.05	2.95	3.25	1.95	1.80	1.80	1.32	9.70	1.05	—.05	1.20	1.52
12	2.17	2.70	2.65	1.70	1.80	3.55	1.55	6.15	.92	.62	1.02	1.42
13	2.07	2.05	2.60	1.50	1.50	4.85	1.60	3.75	1.47	.63	1.78	1.68
14	2.00	1.90	2.50	1.40	1.50	2.63	1.42	2.65	3.97	.65	2.88	1.55
15	1.82	2.15	2.45	1.40	2.40	1.73	1.22	1.82	10.75	.68	2.38	1.58
16	1.55	2.30	2.40	1.40	2.40	1.43	1.22	1.52	9.06	.28	1.68	1.68
17	1.45	1.55	2.25	1.45	3.70	1.40	.87	1.27	3.27	.02	1.58	1.72
18	1.42	1.60	2.10	1.40	4.05	1.33	.65	1.37	1.82	.25	1.48	1.68
19	1.55	2.05	2.05	1.35	8.00	1.30	.92	1.40	1.07	.70	1.42	1.58
20	1.27	4.20	2.10	1.35	4.40	1.23	.67	1.52	1.37	.62	.88	1.38
21	1.45	4.00	1.80	1.30	2.70	2.50	.68	1.37	1.37	.52	.48	1.68
22	1.70	8.50	1.65	1.30	2.25	2.05	.77	3.77	1.37	1.42	.58	1.78
23	2.85	11.05	2.10	1.30	1.70	1.78	2.15	3.37	1.37	.68	1.62	1.50
24	3.00	8.05	5.45	1.30	1.60	1.48	4.67	2.27	1.37	.38	1.52	1.62
25	2.90	4.55	9.70	1.30	1.55	1.28	6.30	1.50	1.12	.35	1.50	1.62
26	2.10	3.80	5.30	1.35	1.50	1.02	2.50	1.37	1.13	1.18	1.40	1.95
27	1.95	3.05	4.05	1.60	1.35	.85	2.05	1.27	1.32	1.05	.82	2.35
28	1.75	3.15	3.80	2.35	1.30	1.32	2.10	1.05	1.32	.85	.38	2.10
29	.82	2.55	3.55	3.25	1.15	1.95	2.97	.72	1.28	.68	1.18	1.98
30	.88	.....	2.80	2.80	1.10	2.77	4.17	.85	1.22	.45	1.42	1.78
31	1.08	.....	2.45	.....	1.00	.....	4.52	1.07	.....	.28	.....	1.75

a Ice.

Rating table for Dan River at South Boston, Va., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.00	400	1.70	1,635	3.40	2,989	6.20	5,453
.10	451	1.80	1,713	3.50	3,070	6.40	5,644
.20	510	1.90	1,791	3.60	3,152	6.60	5,838
.30	574	2.00	1,870	3.70	3,234	6.80	6,034
.40	642	2.10	1,949	3.80	3,317	7.00	6,234
.50	713	2.20	2,028	3.90	3,400	7.20	6,434
.60	786	2.30	2,107	4.00	3,484	7.40	6,638
.70	861	2.40	2,186	4.20	3,653	7.60	6,845
.80	937	2.50	2,265	4.40	3,824	7.80	7,055
.90	1,014	2.60	2,345	4.60	3,997	8.00	7,275
1.00	1,091	2.70	2,425	4.80	4,172	8.50	7,830
1.10	1,168	2.80	2,505	5.00	4,349	9.00	8,415
1.20	1,245	2.90	2,585	5.20	4,528	9.50	9,030
1.30	1,323	3.00	2,665	5.40	4,709	10.00	9,700
1.40	1,401	3.10	2,746	5.60	4,892	10.50	10,420
1.50	1,479	3.20	2,827	5.80	5,077	11.00	11,190
1.60	1,557	3.30	2,908	6.00	5,264	11.50	11,990

The above table is applicable only for open-channel conditions. It is based upon discharge measurements made during 1903 and 1904. It is fairly well defined. The table has been extended below gage height 0.75 foot.

Estimated monthly discharge of Dan River at South Boston, Va., for 1904.

[Drainage area, 2,750 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	2,665	750	1,663	0.605	0.697
February	11,270	1,518	3,239	1.18	1.27
March	9,290	1,596	2,847	1.04	1.20
April	2,868	1,323	1,663	.605	.675
May	7,275	1,091	1,999	.727	.838
June	4,755	976	2,147	.781	.871
July	5,548	824	1,877	.683	.788
August	11,430	876	2,901	1.05	1.21
September	10,795	1,029	2,250	.818	.913
October	1,417	375	772	.281	.324
November	2,569	608	1,233	.448	.500
December	4,510	1,245	1,953	.710	.819
The year	11,430	375	2,045	.744	10.11

MAYO RIVER AT MADISON, N. C.

This station was established as a bench-mark station April 16, 1904, by B. S. Drane. It is located about one-half mile from Madison, N. C., at the highway bridge on the road to Mayodan, N. C., and about 1,000 feet above the junction of Mayo and Dan rivers. Discharge measurements are made from the downstream side of the two-span bridge resting on three stone piers. The initial point for soundings is over the left end of the bridge, downstream side. The channel is straight for about 600 feet above and 1,000 feet below the station. The current is swift. Both banks are high, wooded, and not liable to overflow. The bed of the stream is composed of sand, with some rock along the left bank. There is but one channel. At low stages all water passes under the left span; at higher stages, under both spans. Two cotton mills about 3 miles upstream will control the flow at all times, and freshets in Dan River will also cause backwater at the station. The bench mark is the upper edge of a small tie plate on the upstream side of the bottom of the third strut from the left bank on the upstream side of the bridge. Its elevation is 28 feet above datum.

Discharge measurements of Mayo River at Madison, N. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
April 16	B. S. Drane	59	249	1.13	1.82	281
June 7	do	60	270	.90	2.09	244
September 27	do	61	250	.81	1.24	202

BANISTER RIVER AT HOUSTON, VA.

This river, which drains a total area of 520 square miles, has its headwaters in Pittsylvania County, Va., flows southwesterly through this and Halifax counties, and is tributary to Dan River at a point about 5 miles below South Boston. The basin is hilly and generally in farming lands, with small forest areas. This station was established September 28, 1904, by R. H. Bolster, and is located at a covered highway bridge one and a fourth miles below the railway station at Houston, Va., and about one-fourth of a mile below the mouth of Terrible Creek. A standard chain gage is attached to the upstream side of the bridge near the left pier; the length of chain is 33.50 feet. A board gage at the mouth of Terrible Creek has been set to read the same as the chain gage at 2.3 feet above gage datum and has been used since November 27. A high-water gage from 19 to 30 feet is painted on the northeast corner of Mr. Yates's mill.

The datum of the chain gage is referred to bench marks as follows: No. 1, chiseled cross at the top of the left abutment, upstream side of bridge; elevation, 25.27 feet. No. 2, top of foundation at northeast corner of Mr. Yates's mill, directly under the high-water gage; elevation, 19.12 feet. No. 3, nail in 10-inch tree 50 feet northeast of bridge over Terrible Creek; elevation, 16.48 feet.

The channel is straight for about 1,000 feet above and below the station. Both banks are low and liable to overflow. The bed of the stream is of gravel and sand, and probably changes somewhat. There is one channel, broken by one pier at low water and by two piers at medium stages. The gage is read twice daily by J. A. Yates.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Banister River at Houston, Va., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
September 28 ..	R. H. Bolster.....	73	126	1.44	2.31	181
October 22.....	.....do	72	131	1.24	2.30	162

Mean daily gage height, in feet, of Banister River at Houston, Va., for 1904.[a]

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1.....	2.05	2.12	2.32	12.....	2.00	2.25	2.65	23.....		2.15	2.38	2.78
2.....	2.00	2.22	2.32	13.....	1.95	2.92	2.68	24.....		2.10	2.38	2.98
3.....	2.00	2.20	3.08	14.....	1.95	4.05	2.40	25.....		2.00	2.32	3.65
4.....	2.00	2.25	3.15	15.....	1.95	3.10	2.38	26.....		2.20	2.32	3.35
5.....	2.05	2.52	3.80	16.....	1.90	2.65	2.48	27.....		2.20	2.30	3.50
6.....	2.00	2.48	6.08	17.....	2.00	2.48	2.68	28.....	2.15	2.12	2.30	3.88
7.....	2.00	2.32	4.60	18.....	1.90	2.35	2.85	29.....	2.70	2.15	2.30	3.55
8.....	2.00	2.28	3.40	19.....	2.05	2.35	2.72	30.....	2.28	2.10	2.32	2.95
9.....	1.90	2.28	3.05	20.....	2.00	2.30	2.85	31.....		2.10		2.98
10.....	2.00	2.20	2.90	21.....	2.35	2.30	2.80					
11.....	1.95	2.25	2.75	22.....	2.30	2.35	2.62					

[a] Gage heights from September 28 to November 26 refer to the bridge gage. For the remainder of the year they refer to the gage at the mouth of Terrible Creek.

PEDEE, OR YADKIN, RIVER DRAINAGE BASIN.

The Yadkin River, or the Pedee, as it is called below the junction with the Uharie, rises on the eastern slope of the Blue Ridge, in Caldwell and Watauga counties, N. C., and flows at first southeast, then turns abruptly northeast and flows in this direction for about 60 miles, then bends again abruptly and flows south and southeast across North Carolina and South Carolina, emptying into Winyah Bay at Georgetown, S. C. The total length of the stream, from source to

mouth, following its general direction, is from 275 to 300 miles, while it is probably 400 miles or more if all the windings be followed.

The Pedee drains a total area of about 17,000 square miles, of which about 9,700 square miles are in North Carolina and 7,300 in South Carolina. The stream crosses the fall line near Cheraw, S. C., in a series of rapids extending over a number of miles, with no very great fall at any one place or in any short distance.

Small amounts of power may be developed on some of the tributaries of this stream in South Carolina, but the power possibilities of the basin in this State are unimportant. In North Carolina the stream can be made to furnish power in large quantities at a number of places, and large amounts may be secured on many of the tributaries. This stream and its tributaries are among the most important power streams in the Southern States.

Below the great bend, where the river turns to the south, the valley of the stream averages about 50 miles in width. At many points the river is bordered by wide expanses of bottom lands, which are at times subject to overflow, and which are fertile and very productive. At other places the river is confined between bold and abrupt banks, and in one case it flows for several miles in a very narrow channel, only 60 feet wide in places, in a deep ravine between the flanking hills, forming the noted "Narrows." Above the great bend the valley is only from 15 to 20 miles wide, and the elevations of the divides which separate the basin of the Yadkin from those adjacent are much higher, so that the tributary streams have a large fall.

The upper part of the drainage basin is rough and mountainous and largely forest covered, and throughout this part of its course the flow of the stream is more constant than would be expected.

The average rainfall over the part of the basin in North Carolina is probably between 48 and 51 inches, approximating the lower figure over the lower portions, and possibly exceeding 51 inches over the higher and more mountainous portions, the precipitation increasing as the stream is ascended. This total amount is rather evenly distributed among the seasons.

The highest flood ever known at Wilkesboro, it is stated, occurred in March, 1899, the stream at this place rising 28 feet above low water. The greatest flood recorded at the gaging station at Salisbury, N. C., occurred in December, 1901, the stream reaching an extreme height on the gage of 19.7 feet and having a probable discharge of about 130,000 second-feet, or about 38 second-feet per square mile. The flood of March, 1899, produced a rise of about 1 foot less than this flood of December. The most destructive flood ever experienced on the stream occurred in May, 1901, but the recorded gage height at the Salisbury station was less for this flood than for either of the others

mentioned, and the general testimony of those living along the banks is to the same effect.

The minimum recorded flow at the Salisbury station occurred in September, October, and November, 1897, when the basin of the stream experienced the most severe drought in its history. The flow fell to 900 second-feet several times during this period, or the basin above the station was discharging at an average rate of 0.26 second-foot per square mile. The maximum flow is thus about 144 times the minimum.

The United States Weather Bureau maintains river stations at this basin as follows:

Pedee at Cheraw, S. C.
Pedee at Smiths Mills, S. C.

During 1904 the United States Geological Survey has maintained gaging stations in this drainage basin as follows:

Yadkin at Salisbury, N. C.
Yadkin at North Wilkesboro, N. C.
Reddie at North Wilkesboro, N. C.
Mulberry, at North Wilkesboro, N. C.
Roaring at Roaring River, N. C.
Mitchell at Burch, N. C.
Fisher at Crotchfield, N. C.
Ararat at Siloam, N. C.

YADKIN RIVER NEAR SALISBURY, N. C.

This station was established by C. C. Babb, September 24, 1895, at the Southern Railway bridge about 6 miles east of Salisbury, N. C. Measurements were made from the decked railroad bridge, from which the original wire gage was also suspended. During the year 1899 the location of the measuring station and wire gage was changed to a new iron highway bridge about 300 yards above, the gage being set to read the same as the original one. Early in 1903 it was decided that the original location at the railroad bridge was better; so the station was again changed to it, but the gage was located on the plank walk supported by the lower members of the bridge. The new gage is a standard gage, and is fastened to lower member of the bridge along the plank walk, near the middle of the first span from right bank. The length of the gage chain from the end of the weight to the marker is 28.66 feet.

Bench mark No. 1 is the top of the inside eyebar of the lower chord on the downstream side, in the fourth panel from the right end of the bridge, opposite a point 80 feet from the initial point for soundings. It is marked with white paint and has an elevation of 27.28 feet above gage datum. Bench mark No. 2 is the top of the anchor-bolt head at the right downstream corner of the foot plate on the right abutment.

downstream side. Its elevation is 26.82 feet above gage datum. The discharge measurements are made from the walk to which the gage is attached. The bridge is a four-span iron bridge of the decked type, having a total length of about 650 feet between stone abutments, the left bank abutment being at the edge of the high rocky bluff, while that at right bank is connected with the hill by a short earth embankment. The river is confined by the abutments at all stages, and occupies practically the whole width at low water.

The channel is straight for a long distance below, but curves considerably above. The bed of the river is rocky, and the depth of water is fairly uniform. Current is good, even at lowest stages. The initial point for soundings is the end of the bridge at right bank. The gage is read once daily by J. T. Yarbrough, the bridge keeper.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Yadkin River near Salisbury, N. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
February 16	B. S. Drane	523	2,061	1.38	2.06	2,843
March 17	do	522	2,132	1.44	2.19	3,075
April 25	do	523	2,090	1.22	2.08	2,543
July 22	do	564	1,332	1.96	1.94	2,611
Do	do	528	2,128	1.38	2.22	2,942
September 7	do	524	2,184	1.78	2.52	3,892
September 28	do	520	1,779	.82	1.44	1,465
Do	do	562	1,120	1.36	1.42	1,526
December 17	do	522	1,942	1.08	1.82	2,090

Measurements made at different sections.

Mean daily gage height, in feet, of Yadkin River near Salisbury, N. C., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.75	1.95	2.46	2.00	1.85	2.30	4.20	2.35	1.65	1.35	1.35	1.45
2	1.85	1.74	2.35	2.05	1.95	4.65	3.05	2.25	3.10	1.25	1.35	1.50
3	1.90	1.80	2.25	1.95	1.75	5.10	2.60	3.00	3.00	1.25	1.35	1.95
4	1.92	1.88	2.20	2.05	1.80	3.10	2.25	2.55	2.35	1.30	1.50	2.30
5	1.65	1.90	2.15	1.90	2.05	2.55	2.05	2.05	2.80	1.25	1.75	2.15
6	1.30	1.85	2.00	1.85	2.10	2.30	1.85	2.40	3.15	1.30	2.10	3.00
7	1.45	2.05	2.20	1.85	1.90	2.10	2.10	2.65	2.50	1.30	2.05	3.05
8	1.85	3.35	a 5.20	1.95	2.20	3.00	1.90	4.85	2.15	1.35	1.60	2.55
9	1.85	3.45	4.55	1.90	2.35	2.45	1.80	3.70	1.80	1.35	1.50	2.00
10	1.90	2.75	3.25	2.35	2.75	2.05	2.05	3.50	1.70	1.30	1.45	1.90
11	1.98	2.25	2.75	2.20	2.25	2.25	2.45	3.65	2.05	1.30	1.50	1.80

a Extreme height March 8, 1904, 4 p. m. was 6 feet.

Mean daily gage height, in feet, of Yadkin River near Salisbury, N. C., for 1904— Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
12	1.85	2.15	2.50	1.90	2.25	4.20	1.95	3.80	1.80	1.80	1.50	1.85
13	1.80	2.10	2.40	1.85	2.00	3.25	1.85	3.00	1.60	1.25	1.45	1.70
14	1.85	2.04	2.40	1.80	1.85	2.30	1.80	2.45	1.65	1.30	2.70	1.70
15	1.82	2.10	2.35	1.80	2.35	2.00	1.65	2.15	1.60	1.20	2.65	1.65
16	1.78	2.00	2.25	1.80	2.35	1.90	1.85	2.80	1.60	1.10	2.05	1.65
17	1.78	1.96	2.05	1.90	1.95	1.85	1.85	3.80	1.60	1.25	1.70	1.65
18	1.90	1.80	1.95	1.95	2.00	2.60	1.85	2.90	1.50	1.20	1.60	1.70
19	1.64	1.75	1.95	1.75	6.60	2.50	1.65	2.25	1.50	1.20	1.60	1.85
20	1 70	3.00	2.10	1.75	4.25	2.50	1.55	2.00	1.50	1.30	1.50	1.70
21	1.68	2.80	2.10	1.70	2.85	2.35	1.55	2.50	1.50	1.25	1.65	1.65
22	1.68	3.95	1.95	1.70	2.40	2.10	1.70	2.85	1.50	1.30	1.50	1.60
23	1.95	5.10	2.05	1.70	2.30	2.25	2.15	2.45	1.50	1.20	1.55	1.60
24	2.60	4.20	2.30	1.70	2.00	1.90	3.55	2.30	1.50	1.20	1.60	1.65
25	2.38	3.10	4.40	1.90	1.95	1.80	2.85	2.45	1.40	1.20	1.60	1.85
26	1.95	2.55	3.30	1.75	1.85	1.65	2.25	2.50	1.45	1.30	1.55	1.95
27	1.85	2.48	2.65	2.00	1.90	1.75	2.30	1.90	1.45	1.35	1.45	2.05
28	1.92	2.70	2.70	2.30	1.85	2.05	2.55	1.95	1.40	1.35	1.55	2.65
29	1.75	2.68	2.35	2.00	1.75	4.05	3.15	1.90	1.50	1.35	1.50	2.85
30	1.60	.....	2.10	1.90	1.85	6.35	5.05	1.65	1.35	1.30	1.45	2.50
31	1.78	.....	2.05	.....	1.70	.....	3.00	1.65	.....	1.30	.....	2.05

Rating table for Yadkin River near Salisbury, N. C., from January 1, 1904, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.10	1,050	2.20	3,015	3.30	6,250	4.80	11,780
1.20	1,170	2.30	3,270	3.40	6,585	5.00	12,600
1.30	1,300	2.40	3,540	3.50	6,930	5.20	13,440
1.40	1,445	2.50	3,820	3.60	7,280	5.40	14,280
1.50	1,600	2.60	4,110	3.70	7,630	5.60	15,120
1.60	1,770	2.70	4,400	3.80	7,985	5.80	15,960
1.70	1,950	2.80	4,695	3.90	8,345	6.00	16,800
1.80	2,140	2.90	4,995	4.00	8,710	6.50	18,900
1.90	2,340	3.00	5,300	4.20	9,455		
2.00	2,550	3.10	5,610	4.40	10,220		
2.10	2,775	3.20	5,925	4.60	10,990		

The above table is applicable only for open-channel conditions. It is based upon 9 discharge measurements made during 1904 and 10 made during 1903. It is fairly well defined between gage heights 1.40 feet and 2.60 feet. The table has been extended below gage height 1.40 feet. Above gage height 5 feet the rating curve is a tangent, the difference being 420 per tenth.

Estimated monthly discharge of Yadkin River near Salisbury, N. C., for 1904.

[Drainage area, 3,399 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	4,110	1,300	2,226	0.655	.755
February	13,020	2,026	4,151	1.22	1.32
March	13,440	2,445	4,177	1.23	1.34
April	3,405	1,950	2,370	.697	.778
May	19,320	1,950	3,521	1.04	1.20
June	18,270	1,860	4,770	1.40	1.56
July	12,810	1,685	3,624	1.07	1.23
August	11,987	1,860	4,434	1.30	1.50
September	5,768	1,372	2,376	.699	.780
October	1,372	1,050	1,268	.373	.430
November	2,775	1,372	1,931	.568	.634
December	5,455	1,523	2,630	.774	.892
The year	19,320	1,050	2,873	.919	12.42

YADKIN RIVER AT NORTH WILKESBORO, N. C.

This station was established April 10, 1903, by E. W. Myers. It is located at the lower highway bridge between Wilkesboro and North Wilkesboro, about one-half mile below North Wilkesboro railroad station and about three-fourths of a mile below the mouth of Reddie River. The scale of the standard chain gage is fastened to the downstream guard rail with its zero 7.63 feet east of the center of the second strut from the west end of the span. The distance from the end of the weight to the marker is 33.38 feet.

Bench mark No. 1 is the top surface of the outer eyebar of the lower chord opposite a point 100 feet from the initial point for soundings. When the gage reads zero the water surface is 30.75 feet below this bench mark. Bench mark No. 2 is the top corner of the pulley frame above the hole in the box which incloses the chain. When the gage reads zero the water surface is 31.88 feet below this bench mark.

Discharge measurements are made from the downstream side of the steel highway bridge to which the gage is attached. The bridge consists of a single steel span about 125 feet long, under which the river flows at ordinary stages, and three wooden spans about 50 feet each on the right bank. There are also wooden trestle approaches about 170 feet long on the right bank and about 40 feet on the left

bank. The initial point for soundings is the end of the downstream guard rail at the left end of the bridge. Distances are measured along this guard rail and are marked in white paint. The channel is straight above the station, but makes a very slight curve beneath the bridge. Below the station the channel is straight for about 600 feet. The water is swift both above and below. The right bank is low and is subject to overflow, but all water must pass beneath the bridge and its approaches. The left bank is high and rocky and does not overflow at the bridge. Above the bridge it (the left bank) is subject to overflow. The bed of the stream is rocky, with sand in places. There is a single channel at all stages. The gage was read once each day during 1904 by U. H. Wyatt.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Yadkin River at North Wilkesboro, N. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
March 11	B. S. Drane	95	434	2.30	1.17	1,000
March 12	do	95	399	2.26	.92	903
April 18	do	93	308	1.87	.31	574
April 19	do	93	306	1.88	.26	575
June 8	do	96	396	2.54	1.24	1,004
Do	do	96	396	2.55	1.22	1,009
September 22	do	93	218	2.13	.09	465
Do	do	93	218	1.96	.09	428
December 21	do	92	229	2.13	.07	452
Do	do	92	226	2.06	.03	432

Mean daily gage height, in feet, of Yadkin River at North Wilkesboro, N. C., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.30	[a]0.40	0.85	0.60	0.20	4.60	2.50	1.25	0.50	0.00	−0.05	-0.05
2	.30	−[b].20	.80	.50	.20	2.70	1.25	1.20	.70	.00	− .05	− .05
3	.30	[a].40	.70	.45	1.30	1.75	.90	1.35	.45	.00	− .05	.20
4	−[b].05	[b].20	.65	.40	2.20	1.40	.75	.70	.40	− .05	.25	.10
5	−[b].05	[b].20	.50	.35	1.10	1.10	1.00	.95	2.40	.05	1.30	.10
6	.10	[a].50	.40	.30	.90	2.15	1.15	1.50	.85	.00	.25	1.30
7	.40	.50	7.50	.50	.90	1.45	.80	.75	.60	.00	.00	.40
8	.20	1.95	8.70	.50	1.10	1.50	1.35	2.25	.50	.00	.00	.20
9	.20	.85	2.10	1.05	2.90	.95	.70	1.20	.45	− .05	.00	.10
10	.25	.60	1.50	.55	2.20	.95	1.20	2.15	.40	- .10	.00	.10
11	.25	.55	1.20	.50	1.60	1.50	.70	1.60	.40	- .10	- .05	.10
12	.30	.45	.90	.40	1.20	1.10	.85	1.20	.45	− .10	.05	.05
13	.30	.30	.75	.35	.95	.85	.55	.95	.40	− .10	.60	.00

[a] Thaw. [b] Freeze.

Mean daily gage height, in feet, of Yadkin River at North Wilkesboro, N. C., for 1904—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
14	.30	.40	.80	.30	.75	.70	.40	.90	.55	— .10	.75	— .10
15	a.00	.35	.70	.25	.90	.65	.40	1.70	.30	— .10	.20	.00
16	b.20	.30	.55	.20	.60	.65	.40	1.60	.20	— .10	.10	.00
17	.25	.10	.50	.25	.50	1.95	.60	.75	.20	— .10	.00	.10
18	.05	.30	.50	.25	9.80	.90	.35	.50	.10	— .10	.00	.10
19	—a.05	.30	.50	.25	8.40	.90	.25	.40	.10	— .10	.00	— .10
20	— .20	.45	.45	.20	2.00	1.00	.20	1.05	.10	— .10	.00	— .10
21	b.30	.30	.55	.20	1.40	.75	.20	1.20	.10	— .10	.00	— .10
22	.35	2.35	.80	.20	1.10	.70	.20	1.25	.10	— .10	.00	— .05
23	.20	1.90	.65	.20	.90	.50	.20	.75	.00	— .15	.00	— .05
24	.90	1.15	1.60	.20	.75	.45	.30	4.50	.00	— .15	.00	.00
25	.60	.80	1.25	.20	.90	.40	1.60	1.40	.00	— .15	— .10	.10
26	.50	.70	1.00	.65	.90	.50	1.20	1.05	10	— .15	— .10	.05
27	.35	.80	1.10	.65	.60	.55	.45	.80	.10	— .05	— .10	.30
28	.35	.90	.85	.40	.50	4.80	.95	.65	.05	— .05	— .10	1.70
29	a.25	.90	.70	.30	.40	2.50	6.70	.60	.05	— .05	— .10	.60
30	a.10	.....	.60	.25	.80	1.65	1.35	.50	.00	— .05	— .05	.15
31	a.10	.....	.60	.....	1.70	.....	.85	.45	.....	— .05	.....	.25

a Freeze. b Thaw.

Rating table for Yadkin River at North Wilkesboro, N. C., from January 1, 1904, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.00	417	.60	710	1.20	1,010	1.80	1,345
.10	465	.70	760	1.30	1,060	1.90	1,410
.20	513	.80	810	1.40	1,115	2.00	1,475
.30	562	.90	860	1.50	1,170		
.40	611	1.00	910	1.60	1,225		
.50	660	1.10	960	1.70	1,285		

The above table is applicable only for open-channel conditions. It is based upon 10 discharge measurements made during 1904. It is well defined between gage heights 0 feet and 1.30 feet. The table has been extended beyond these limits. Above gage height 2 feet the discharge has been estimated.

Estimated monthly discharge of Yadkin River at North Wilkesboro, N. C., for 1904.

[Drainage area 498 square miles.]

Room.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	860	322	532	1.07	1.23
February	1,730	322	742	1.49	1.61
March	9,300	611	1,171	2.35	2.71
April	935	513	602	1.21	1.35
May	14,500	513	1,467	2.95	3.40
June	4,375	611	1,224	2.46	2.74
July	7,650	513	1,032	2.07	2.39
August	3,950	611	1,059	2.13	2.46
September	1,770	417	594	1.19	1.33
October	417	345	381	.765	.882
November	1,060	369	461	.926	1.03
December	1,285	369	506	1.02	1.18
The year	14,500	322	814	1.64	22.31

REDDIE RIVER AT NORTH WILKESBORO, N. C.

This station was established as a bench-mark station April 18, 1904, by B. S. Drane. It is located at the highway bridge just without the town of North Wilkesboro, N. C., and about one-half mile above the mouth of Reddie River. Discharge measurements are made from the downstream side of the single-span, covered, bridge, the meter being lowered outside the floor. The initial point for soundings is the left end of the bottom rail downstream hand rail. The channel is straight for about 500 feet above and below the station. The current is swift. Both banks are high and not subject to overflow. The bed of the stream is composed of sand, and is somewhat shifting. There is only one channel for all stages. A small lumber mill and dam a short distance above the station will affect the flow during low water. The bench mark is the upper edge of the lower rail of the downstream guard rail, by the side of a notch, 66 feet from the initial point for soundings. Its elevation is 27 feet above datum.

Discharge measurements of Reddie River at North Wilkesboro, N. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
April 18	B. S. Drane	57	61	1.22	1.98	75
June 9	do	59	91	1.69	2.26	153
September 23	do	50	51	1.57	1.66	80

MULBERRY RIVER NEAR NORTH WILKESBORO, N. C.

This station was established as a bench-mark station November 7, 1903, by B. S. Drane. It is located at the Southern Railway bridge about 2 miles east of North Wilkesboro, N. C., and less than one-half mile above the mouth of Mulberry River. Discharge measurements are made from the downstream side of the bridge. The initial point for soundings is the streamward face of the left trestle bent. The channel is curved for 100 feet above and below the station. The current is swift. The right-bank approach is over a long trestle and the stream overflows under this during high stages. The left bank is rocky and the section is bounded by the masonry abutment of the railroad fill. The bed of the stream is rocky along the left bank, sandy along the right bank, and is permanent. There is but one channel. The current is broken at all but the lowest stages by one or more of the trestle bents supporting the bridge. High water in Yadkin River will probably back up to this point. The bench mark is the apex of the triangular downstream end of the iron bearing through which pass the iron tension rods midway between the ends of the truss, on the downstream side of the bridge, about 2 feet east of the second bent from the left bank. Its elevation is 24 feet above datum.

Discharge measurements of Mulberry River near North Wilkesboro, N. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
April 19	B. S. Drane	15	25	1.62	1.12	41
June 8	do	25	31	1.98	1.30	61
September 22	do	21	21	1.37	.91	29

ROARING RIVER AT ROARING RIVER, N. C.

This station was established as a bench-mark station April 20, 1904, by B. S. Drane. It is located at the Southern Railway bridge, a short distance above the mouth of Roaring River, at Roaring River, N. C.

Discharge measurements are made from the downstream side of the one-span bridge. The initial point for soundings is on the downstream guard-rail, exactly over the left end of the bridge. The channel is straight for about 200 feet above and 500 feet below the station. The current is swift. The banks rise gradually, but all water passes beneath the bridge and its approaches. The bed of the stream is composed of sand and gravel and is slightly shifting. There is but one channel at all stages, broken during high water by the piers and trestle approaches of the bridge. High water in Yadkin River will make this site of no value as a gaging station, but it is good at ordinary stages. The bridge crosses the river almost at right angles to the current. The bench mark is the edge of the outermost eyebar of the downstream lower chord, at a point midway between the ends of the bridge opposite the iron tension rods. Its elevation is 27 feet above gage datum.

Discharge measurements of Roaring River at Roaring River, N. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
April 20	B. S. Drane	62	103	1.20	1.55	125
June 9	do	78	105	1.70	1.93	178
September 23	do	63	53	1.36	1.10	72

MITCHELL RIVER AT BURCH, N. C.

This station was established as a bench-mark station April 20, 1904, by B. S. Drane. It is located at the Southern Railway bridge at Burch, N. C., a few hundred feet above the mouth of Mitchells River. Discharge measurements are made from the downstream side of the one-span railway bridge. The initial point for soundings is the end of the downstream guard-rail at the left end of the bridge. The channel is straight for about 700 feet above and 300 feet below the station. Both banks are high, clean, and not liable to overflow. The bed of the stream is composed of sand and gravel, and is slightly shifting. There is but one channel at all stages. Good measurements can be made at ordinary stages, but high water in Yadkin River renders the station of no value as a gaging point. The bridge crosses the stream diagonally. The bench mark is the upper edge of the outermost eyebar of the lower chord, downstream side, midway between the ends of the bridge, 62.5 feet from the initial point for soundings. Its elevation is 27 feet above datum.

Discharge measurements of Mitchell River at Burch, N. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
April 20	B. S. Drane	84.5	169	.57	2.07	96
September 23	do	65	150	.46	1.99	69

FISHER RIVER NEAR CRUTCHFIELD, N. C.

This station was established as a bench-mark station April 20, 1904, by B. S. Drane. It is located about 2 miles east of Crutchfield, N. C., at the Southern Railway bridge, just above the mouth of the river. Discharge measurements are made from the upstream side of the one-span bridge. The initial point for soundings is the right end of the upstream guard rail. The channel is curved for about 500 feet above and 100 feet below the station. The current is very sluggish. Both banks are high, and not liable to overflow. The bed of the stream is composed of deep mud and silt, and is obstructed along the right bank by the ironwork of an old bridge burned here. There is but one channel for all stages.

High water in Yadkin River will make the station valueless at such times, and the station has little to recommend it except its accessibility. Bench mark No. 1 is the upstream edge of the upper surface of the I beam forming the upstream lower chord, at a point 96 feet from the initial point for soundings. Its elevation is 27 feet above datum. Bench mark No. 2 is the upper edge of the head of a large wire nail driven into a triangular-shaped blaze in the downstream face of a large willow tree on the left bank, 100 yards above the bridge. Its elevation is 12.15 feet above gage datum.

Discharge measurements of Fisher River near Crutchfield, N. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
April 20	B. S. Drane	87	265	0.59	1.40	156
September 24	do	103	320	.25	1.06	80

ARARAT RIVER NEAR SILOAM, N. C.

This station was established as a bench-mark station April 21, 1904, by B. S. Drane. It is located at the Southern Railway bridge about 1 mile east of Siloam, N. C., and a short distance above the mouth of the river. Discharge measurements are made from the downstream

side of the single-span bridge, having a short trestle approach at each end. The initial point for soundings is a point on the downstream guard rail at the left end of the truss. The channel is straight for about 500 feet above and 150 feet below the station. The current is swift. Both banks slope gradually. All water passes beneath the bridge and approaches. The bed of the stream is composed of sand, free from vegetation, and somewhat shifting. There is but one channel at all stages. Flood stages will flow around the cribwork pier on each bank, supporting the ends of the iron bridge.

High water in Yadkin River will make this valueless as a gaging site, but it is a good point for low-water measurements. The bridge crosses the stream almost at right angles. The bench mark is the surface of the outer eyebar of the lower chord of the bridge, downstream side, exactly midway between the ends of the bridge, just outside the iron tension rods. Its elevation is 28 feet above gage datum.

Discharge measurements of Ararat River near Siloam, N. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
April 21	B. S. Drane	111	169	1.64	1.08	277
June 9	do	114	217	1.41	1.63	306
September 24	do	111	210	.81	.80	170

MISCELLANEOUS DISCHARGE MEASUREMENTS IN THE YADKIN BASIN.

The following is a list of miscellaneous discharge measurements made in the Yadkin River drainage basin during 1904:

Yadkin River at Crutchfield, N. C.—A gaging made from the ferry April 21 gave the following results: Width, 227 feet; area, 690 square feet; mean velocity, 1.48 feet per second; discharge, 1,023 second-feet. No bench marks were established, but the gage at Salisbury showed a uniform stage of 1.70 feet gage height from April 21 to 24.

Elkin Creek at Elkin, N. C.—This stream enters Yadkin River from the north at the town of Elkin, N. C. Gagings have been made from the Southern Railway bridge, just above the mouth of the creek, as follows: April 19—width, 26 feet; area, 68 square feet; mean velocity, 0.36 foot per second; gage height, 0.80 foot; discharge, 24 second-feet. June 9—width, 26 feet; area, 59 square feet; mean velocity, 0.46 foot per second; gage height, 1.14 feet; discharge, 27 second-feet. The bench mark is the top of the outer eyebar of the downstream lower chord on the right side of the second strut from the left end of the bridge. Its elevation is 25 feet above the datum of the gage.

INDEX.

	Page.
Antietam Creek near—	
Sharpsburg, Md.:	
description	67–68
discharge	68
discharge, monthly	69
gage heights	68
rating table	69
Appomattox River at—	
Mattoax, Va.:	
description	91–92
discharge	92
discharge, monthly	94
gage heights	92
rating table	93
Ararat River at—	
Siloam, N. C.:	
description	118–119
discharge	119
Banister River at—	
Houston, Va.:	
description	106–107
discharge	107
gage heights	107
Belair, Md.	
Little Gunpowder Falls near:	
description	57
discharge	58
Binghamton, N. Y.	
Chenango River at:	
description	18–19
discharge	19
discharge, daily	21
discharge, monthly	22
gage heights	19–20
rating table	20
Susquehanna River at:	
description	18–19
discharge	19
discharge, daily	21
discharge, monthly	22
gage heights	19–20
rating table	20
Broad Creek at—	
Mill Green, Md.:	
description	55–56
Buchanan, Va.	
James River at:	
description	81
discharge	82
Buchanan, Va.—Continued.	Page.
James River at—Continued.	
discharge, monthly	83
gage heights	82
rating table	83
Burch, N. C.	
Mitchell River at:	
description	117
discharge	118
Cartersville, Va.	
James River at:	
description	85
discharge	85
discharge, monthly	88
gage heights	86
rating table	87
Chemung, N. Y.	
Chemung River at:	
description	43–44
discharge	44
discharge, daily	46–47
discharge, monthly	48
gage heights	44–45
rating table	46
Chemung River at—	
Chemung, N. Y.:	
description	43–44
discharge	44
discharge, daily	46–47
discharge, monthly	48
gage heights	44–45
rating table	46
Chenango River at—	
Binghamton, N. Y.:	
description	39
discharge	40
discharge, daily	41–42
discharge, monthly	42
gage heights	40
rating table	41
Churchville, Md.	
Deer Creek at:	
description	56
discharge	56
Crutchfield, N. C.	
Fisher River at:	
description	118
discharge	118
Yadkin River at:	
discharge	119

Dan River at— Page.
Madison, N. C.:
description 100–101
discharge 101
discharge, monthly 102–103
gage heights 101–102
rating table 102
South Boston, Va.:
description 103–104
discharge 104
discharge, monthly 105
gage heights 104
rating table 105
Danville, Pa.
North Branch of Susquehanna River at:
description 27–28
gage heights 28
Deer Creek at—
Churchville, Md.:
description 56
discharge 56
Elkin, N. C.
Elkin Creek at:
description 119
discharge 119
Elkin Creek at—
Elkin, N. C.:
description 119
discharge 119
Fisher River at—
Crutchfield, N. C.:
description 118
discharge 118
Frederick, Md.
Monocacy River near:
description 76–77
discharge 77
discharge, monthly 79
gage heights 77–78
rating table 78
Front Royal, Va.
South Branch of Shenandoah River near:
description 72–73
discharge 73
discharge, monthly 74
gage heights 73
rating table 74
Glasgow, Va.
James River at:
description 88–89
discharge 89
discharge, monthly 91
gage heights 89–90
rating table 90
Glencoe, Md.
Gunpowder Falls near:
description 57
Gunpowder Falls near—
Glencoe:
description 57
Gunpowder River drainage basin:
description 56–57
Harrisburg, Pa.
Susquehanna River at:
description 29–30
Harrisburg, Pa.—Continued. Page.
Susquehanna River at—Cont'd.
discharge 30–31
discharge, monthly 33
gage heights 31
rating table 32
Holcomb Rock, Va.
James River at:
description 84
gage heights 84
Houston, Va.
Banister River at:
description 106–107
discharge 107
gage heights 107
James River at—
Buchanan, Va.:
description 81
discharge 82
discharge, monthly 83
gage heights 82
rating table 83
Cartersville, Va.:
description 85
discharge 85
discharge, monthly 86
gage heights 86
rating table 87
Holcomb Rock, Va.:
description 84
gage heights 84
James River, North Fork, at—
Glasgow, Va.:
description 88–89
discharge 89
discharge, monthly 91
gage heights 89–90
rating table 90
James River drainage basin:
description 79–80
gaging stations 82–84
Juniata River at—
Newport, Pa.:
description 52
discharge 52
discharge, daily 54–55
discharge, monthly 55
gage heights 53
rating table 54
McCall Ferry, Pa.
Susquehanna River at:
description 34–35
discharge 36
discharge, daily 37–38
discharge, monthly 38
gage heights 36
rating table 37
Little Gunpowder Falls, near—
Belair, Md.:
description 57
discharge 58
Madison, N. C.
Dan River at:
description 100–101
discharge 101
discharge, monthly 102–103

Madison, N. C.—Continued. Page.
Dan River at—Continued.
gage heights 101–102
rating table 102
Mayo River at:
description 106
discharge 106
Mattoax, Va.
Appomattox River at:
description 91–92
discharge 92
discharge, monthly 94
gage heights 92
rating table 93
Mayo River at—
Madison, N. C.:
description 106
discharge 106
Mill Green, Md.
Broad Creek at:
description 55–56
Millville, W. Va.
Shenandoah River at:
description 69–70
discharge 70
discharge, monthly 72
gage heights 70–71
rating table 71
Mitchell River at—
Bunch, N. C.:
description 117
discharge 118
Monocacy River near—
Frederick, Md.:
description 76–77
discharge 77
discharge, monthly 79
gage heights 77–78
rating table 78
Mulberry River at—
North Wilkesboro, N. C.:
description 116
discharge 116
Newport, Pa.
Juniata River at:
description 52
discharge 52
discharge, daily 54–55
discharge, monthly 55
gage heights 53
rating table 54
North Wilkesboro, N. C.
Mulberry River near:
description 116
discharge 116
Reddie River at:
description 115
discharge 116
Yadkin River at:
description 112–113
discharge 113
discharge, monthly 115
gage heights 113–114
rating table 114
Patapsco River at— Page.
Woodstock, Md.:
description 58–59
discharge 59
gage heights 59–60
Patapsco River drainage basin:
description 58
Piedmont, W. Va.
North Branch of Potomac River at:
description 61–62
discharge 62
gage heights 62
Point of Rocks, Md.
Potomac River at:
description 63
discharge 64
discharge, monthly 65
gage heights 64
rating table 65
Potomac River at—
Point of Rocks, Md.:
description 63
discharge 64
discharge, monthly 65
gage heights 64
rating table 65
Potomac River, North Branch of, at—
Piedmont, W. Va.:
description 61–62
discharge 62
gage heights 62
Potomac River, South Branch of, near—
Springfield, W. Va.:
description 66
discharge 66
gage heights 67
Potomac River drainage basin:
description 60–61
gaging stations 61
Randolph, Va.
Staunton River at:
description 98
discharge 98
discharge, monthly 100
gage heights 98–99
rating table 99
Reddie River at—
North Wilkesboro, N. C.:
description 115
discharge 116
Riverton, Va.
North Branch of Shenandoah River near:
description 75
discharge 75
gage heights 76
Roanoke, Va.
Roanoke River at:
description 95
discharge 96
discharge, monthly 97
gage heights 96
rating table 97

	Page.
Roanoke River at—	
Roanoke, Va.:	
description	95
discharge	96
discharge, monthly	97
gage heights	96
rating table	97
Roanoke River drainage basin:	
gaging stations	95
description	94–95
Roaring River, N. C.	
Roaring River at:	
description	116–117
discharge	117
Roaring River at—	
Roaring River, N. C.:	
description	116–117
discharge	117
Salisbury, N. C.	
Yadkin River near:	
description	109–110
discharge	110
discharge, monthly	112
gage heights	110–111
rating table	111
Sharpsburg, Md.	
Antietam Creek near:	
description	67–68
discharge	68
discharge, monthly	69
gage heights	68
rating table	69
Shenandoah River at—	
Millville, W. Va.:	
description	69–70
discharge	70
discharge, monthly	72
gage heights	70–71
rating table	71
Shenandoah River, North Branch of, near—	
Riverton, Va.:	
description	75
discharge	75
gage heights	76
Shenandoah River, South Branch of, near—	
Front Royal, Va.:	
description	72–73
discharge	73
discharge, monthly	74
gage heights	73
rating table	74
Siloam, N. C.	
Ararat River at:	
description	118–119
discharge	119
South Boston, Va.	
Dan River at:	
description	103–104
discharge	104
discharge, monthly	105
gage heights	104
rating table	105
Springfield, W. Va.	
South Branch of Potomac River near:	
description	66
discharge	66
gage heights	67
Staunton River at—	
Randolph, Va.:	
description	98
discharge	98
discharge, monthly	100
gage heights	98–99
rating table	99
Susquehanna River at—	
Binghamton, N. Y.:	
description	18–19
discharge	19
discharge, daily	21
discharge, monthly	22
gage heights	19–20
rating table	20
Harrisburg, Pa.:	
description	29–30
discharge	30–31
discharge, daily	32–33
discharge, monthly	33
gage heights	31
rating table	32
McCall Ferry, Pa.:	
description	34–35
discharge	36
discharge, daily	37–38
discharge, monthly	38
gage heights	36
rating table	37
Wilkesbarre, Pa.:	
description	22–23
discharge	23
discharge, daily	26
discharge, monthly	27
gage heights	24
rating table	25
Susquehanna River, North Branch, at—	
Danville, Pa.:	
description	27–28
gage heights	28
Susquehanna River, West Branch, at—	
Williamsport, Pa.:	
description	48–49
discharge	49
discharge, daily	50–51
discharge, monthly	51
gage heights	49
rating table	50
Susquehanna River drainage basin:	
description	17
gaging stations	18
Wilkesbarre, Pa.	
Susquehanna River at:	
description	22–23
discharge	23

	Page.
Wilkesbarre, Pa.—Continued.	
Susquehanna River at—Cont'd.	
discharge, daily	26
discharge, monthly	27
gage heights	24
rating table	25
Williamsport, Pa.	
West Branch of Susquehanna River at:	
description	48–49
discharge	49
discharge, daily	50–51
discharge, monthly	51
gage heights	49
rating table	50
Woodstock, Md.	
Patapsco River at:	
description	58–59
discharge	59
gage heights	59–60
Yadkin River at—	
Crutchfield, N. C.:	
discharge	119
North Wilkesboro, N. C.:	
description	112–113
discharge	113
discharge, monthly	115
gage heights	113–114
rating table	114
Salisbury, N. C.:	
description	109–110
discharge	110
discharge, monthly	112
gage heights	110–111
rating table	111
Yadkin (Pedee) River drainage basin:	
description	107–109
discharge	119
gaging stations	109

PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Water-Supply Paper No. 126.]

The publications of the United States Geological Survey consist of (1) Annual Reports; (2) Monographs; (3) Professional Papers; (4) Bulletins; (5) Mineral Resources; (6) Water-Supply and Irrigation Papers; (7) Topographic Atlas of United States, folios and separate sheets thereof; (8) Geologic Atlas of United States, folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

The Professional Papers, Bulletins, and Water-Supply Papers treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous; H, Forestry; I, Irrigation; J, Water storage; K, Pumping water; L, Quality of water; M, General hydrographic investigations; N, Water power; O, Underground waters; P, Hydrographic progress reports.

Most of the above publications may be obtained or consulted in the following ways:

1. A limited number are delivered to the Director of the Survey, from whom they may be obtained, free of charge, on application.

2. Every member of Congress is allotted a certain number, from whom they may be obtained, free of charge, on application.

3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they may be had at practically cost.

4. Copies of all Government publications are furnished to the principal public libraries in the large cities throughout the United States, where they may be consulted by those interested.

Series P.—The hydrographic progress reports contain the results of stream measurements. A report is issued for every calendar year, containing the results of data collected during that year. These reports were first published as a part of the Director's annual report or as a bulletin; they are now published as water-supply and irrigation papers. The following is a list, by years, of the publications containing the progress reports of stream measurements. A detailed index of these reports is published as Water-Supply Paper No. 119.

1888. Tenth Annual Report, Part II.
1889. Eleventh Annual Report, Part II.
1890. Twelfth Annual Report, Part II.
1891. Thirteenth Annual Report, Part III.
1892. Fourteenth Annual Report, Part II.
1893. Bulletin No. 131.
1894. Bulletin No. 131; Sixteenth Annual Report, Part II.
1895. Bulletin No. 140.
1896. Water-Supply Paper No. 11; Eighteenth Annual Report, Part IV.
1897. Water-Supply Papers Nos. 15 and 16; Nineteenth Annual Report, Part IV.
1898. Water-Supply Papers Nos. 27 and 28; Twentieth Annual Report, Part IV.
1899. Water-Supply Papers Nos. 35, 36, 37, 38, and 39; Twenty-first Annual Report, Part IV.
1900. Water-Supply Papers Nos. 47, 48, 49, 50, 51, and 52; Twenty-second Annual Report, Part IV.
1901. East of the Mississippi River, Water-Supply Papers Nos. 65 and 75.
West of the Mississippi River, Water-Supply Papers Nos. 66 and 75.
1902. East of the Mississippi River, Water-Supply Papers Nos. 82 and 83.
West of the Mississippi River, Water-Supply Papers Nos. 84 and 85.
1903. East of the Mississippi River, Water-Supply Papers Nos. 97 and 98.
West of the Mississippi River, Water-Supply Papers Nos. 99 and 100.
1904. East of the Mississippi River, Water-Supply Papers Nos. 124, 125, 126, 127, 128, and 129.
West of the Mississippi River, Water-Supply Papers Nos. 130, 131, 132, 133, 134, and 135.

The hydrographic branch of the Geological Survey and the Reclamation Service have suboffices in different parts of the United States, from which work in the respective localities is carried on and where data may be obtained on application. These offices are located as follows:

Boston, Mass., 6 Beacon street; Utica, N. Y., 75 Arcade; Atlanta, Ga., 409 Temple court; Austin, Tex., University of Texas; Chicago, Ill., Post-office Building; Belle Fourche, S. Dak.; Cody, Wyo.; Denver, Colo., Chamber of Commerce Building; Salt Lake, Utah; Los Angeles, Cal., 1108 Braly Building; San Francisco, Cal., 417 Rialto Building; Phoenix, Ariz.; Carlsbad, N. Mex.; El Paso, Tex.; Billings, Mont.; Great Falls, Mont.; Hazen, Nev.; Boise, Idaho; Spokane, Wash., 424 Peyton Block; Pendleton, Oreg.

Correspondence should be addressed to

THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, D. C.

LIBRARY CATALOGUE SLIPS.

[Mount each slip upon a separate card, placing the subject at the top of the second slip. The name of the series should not be repeated on the series card, but the additional numbers should be added, as received, to the first entry.]

Author.

Grover, N[athan] C.

. . . Report of progress of stream measurements for the calendar year 1904. Prepared under the direction of F. H. Newell by N. C. Grover and John C. Hoyt. Pt. III.—Susquehanna, Patapsco, Potomac, James, Roanoke, Cape Fear, and Yadkin River drainages. Washington, Gov't print. off., 1905.

125, iii p. illus. II pl. (incl. map) 23cm. (U. S. Geological survey. Water-supply and irrigation paper no. 126)

Subject series: P, Hydrographic progress reports, 31.

1. Stream measurements. 2. Rivers—U. S. I. Hoyt, John Clayton, 1874— joint author.

Subject.

Grover, N[athan] C.

. . . Report of progress of stream measurements for the calendar year 1904. Prepared under the direction of F. H. Newell by N. C. Grover and John C. Hoyt. Pt. III.—Susquehanna, Patapsco, Potomac, James, Roanoke, Cape Fear, and Yadkin River drainages. Washington, Gov't print. off., 1905.

125, iii p. illus. II pl. (incl. map) 23cm. (U. S. Geological survey. Water-supply and irrigation paper no. 126)

Subject series: P, Hydrographic progress reports, 31.

1. Stream measurements. 2. Rivers—U. S. I. Hoyt, John Clayton, 1874— joint author.

Series.

U. S. Geological survey.

Water-supply and irrigation papers.

no. 126. Grover, N. C. Report of progress of stream measurements for . . . 1904 . . . by N. C. Grover and J. C. Hoyt. Pt. III. 1905.

Reference.

U. S. Dept. of the Interior.

see also

U. S. Geological survey.

IRR 126—05——0

Water-Supply and Irrigation Paper No. 127 Series P, Hydrographic Progress Reports, 32

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

REPORT

OF

PROGRESS OF STREAM MEASUREMENTS

FOR

THE CALENDAR YEAR 1904

PREPARED UNDER THE DIRECTION OF F. H. NEWELL

BY

M. R. HALL and JOHN C. HOYT

PART IV.—Santee, Savannah, Ogeechee, and Altamaha Rivers and Eastern Gulf of Mexico Drainages

WASHINGTON
GOVERNMENT PRINTING OFFICE
1905

CONTENTS.

	Page.
Letter of transmittal	5
Introduction	7
Cooperation and acknowledgments	16
Santee River drainage basin	17
Catawba River near Catawba, S. C	20
Catawba River near Morganton, N. C	23
John River near Morganton, N. C	26
Wateree River near Camden, S. C	28
Broad River (of the Carolinas) at Alston, S. C	28
Tiger River at Delta, S. C	31
Enoree River near Whitmire, S. C	32
Saluda River near Waterloo, S. C	32
Reedy River near Waterloo, S. C	35
Miscellaneous measurements	36
Savannah River drainage basin	37
Tallulah River at Tallulah Falls, Ga	37
Tugaloo River near Madison, S. C	39
Savannah River at Augusta, Ga	42
Chauga River near Fort Madison, S. C	46
Seneca River near Clemson College, S. C	46
Rocky River near Calhoun Falls, S. C	49
Broad River (of Georgia) near Carlton, Ga	50
Broad River (South Fork) near Carlton, Ga	53
Miscellaneous measurements	53
Ogeechee River drainage basin	54
Williamsons Swamp Creek at Davisboro, Ga	54
Cannoochee River near Groveland, Ga	56
Altamaha River drainage basin	59
South River near Lithonia, Ga	60
Ocmulgee River near Flovilla, Ga	63
Ocmulgee River at Macon, Ga	66
Alcovy River near Covington, Ga	69
Apalachee River near Buckhead, Ga	72
Oconee River near Greensboro, Ga	75
Oconee River at Millegeville, Ga	78
Oconee River at Dublin, Ga	81
Ohoopee River near Reidsville, Ga	85
Miscellaneous measurements	88
Minor Southern Atlantic drainage basins	90
Miscellaneous measurements	90
Apalachicola River drainage basin	90
Chattahoochee River near Cornelia, Ga	91
Chattahoochee River near Norcross, Ga	92
Chattahoochee River at Oakdale, Ga	95
Chattahoochee River at West Point, Ga	98
Soque River near Demorest, Ga	101
Sweetwater Creek near Austell, Ga	103

	Page.
Apalachicola River drainage basin—Continued.	
Mulberry Creek near Columbus, Ga	105
Flint River near Woodbury, Ga	105
Flint River at Albany, Ga	108
Big Potato Creek near Thomaston, Ga	114
Muckalee Creek near Albany, Ga	114
Kinchafoonee Creek near Albany, Ga	115
Miscellaneous measurements	116
Choctawhatchee River drainage basin	120
Choctawhatchee River near Geneva, Ala	121
Double Bridges Creek at Geneva, Ala	122
Pea River at Pera, Ala	123
Escambia River drainage basin	125
Conecuh River at Beck, Ala	125
Mobile River drainage basin	127
Alabama River at Selma, Ala	127
Etowah River at Canton, Ga	130
Etowah River near Rome, Ga	133
Coosa River at Riverside, Ala	136
Oostanaula River at Resaca, Ga	138
Coosawatee River at Carters, Ga	139
Cartecay River near Cartecay, Ga	142
Ellijay River near Ellijay, Ga	143
Mountaintown Creek near Ellijay, Ga	144
Talking Rock Creek near Carters, Ga	144
Choccolocco Creek near Jenifer, Ala	145
Talladega Creek at Nottingham, Ala	148
Tallapoosa River at Buchanan Bridge, near Tallapoosa, Ga	150
Tallapoosa River at Adderhold Bridge, near Tallapoosa, Ga	151
Tallapoosa River near Heflin, Ala	152
Tallapoosa River at Sturdevant, Ala	153
Little Tallapoosa River 3 miles north of Wedowee, Ala	156
Little Tallapoosa River 6 miles northwest of Wedowee, Ala	157
Cahaba River at Centerville, Ala	157
Tombigbee River at Columbus, Miss	160
Black Warrior River near Cordova, Ala	163
Black Warrior River at Tuscaloosa, Ala	167
Clear Creek near Elk, Ala	169
Black Water Creek near Jasper, Ala	170
Black Warrior River (Locust Fork) at Palos, Ala	171
Miscellaneous measurements	174
Pearl River drainage basin	177
Pearl River at Jackson, Miss	177
Minor Eastern Gulf of Mexico drainage basins	180
Miscellaneous measurements	180
Index	181

ILLUSTRATIONS.

	Page.
PLATE I. Map showing location of principal gaging stations in the United States	8
II. Price current meters, with buzzers	10
FIG. 1. Cable station, showing section of the river, car, gage, etc	9

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
HYDROGRAPHIC BRANCH,
Washington, D. C., April 4, 1905.

SIR: I transmit herewith the manuscript of Part IV of a series of twelve papers which compose the Report of Progress of Stream Measurements for the Calendar Year 1904. Parts I to VI of this report contain the results of the data collected in the territory east of Mississippi River. Parts VII to XII are devoted to the data collected in the territory west of the Mississippi.

The larger part of the original data for this report was collected under the direction of District Hydrographer M. R. Hall, who was assisted by W. E. Hall, J. M. Giles, and B. S. Drane. The assembling of the data and its preparation for publication were done under the direction of John C. Hoyt, who has been assisted by R. H. Bolster, Robert Follansbee, Willis E. Hall, A. H. Horton, H. D. Comstock, and H. M. Morse.

I request that this manuscript be published as one of the series of Water-Supply and Irrigation Papers.

Very respectfully,

F. H. NEWELL, *Chief Engineer.*

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

PROGRESS REPORT OF STREAM MEASUREMENTS FOR THE CALENDAR YEAR 1904.

PART IV.

By M. R. HALL and JOHN C. HOYT.

INTRODUCTION.

The hydrographic work of the United States Geological Survey includes the collection of facts concerning and the study of conditions affecting the behavior of water from the time it reaches the earth as rain or snow until it joins the oceans or great navigable rivers. These investigations became a distinct feature of the work of the Survey in the fall of 1888, when an instruction camp was established at Embudo, N. Mex. Since that date the work has been continually and gradually extended as larger funds became available. The first distinctive appropriation for gaging streams was made by the act of August 18, 1894, which contained an item of $12,500, "for gaging the streams and determining the water supply of the United States, including the investigation of underground currents and artesian wells in the arid and semiarid sections." (Digest of Appropriations for 1895, p. 270.)

Since that time a similar act has been passed each year and the appropriations have gradually increased, as shown in the following table:

Annual appropriations for hydrographic surveys.

Year ending June 30, 1895	$12,500
Year ending June 30, 1896	25,000
Year ending June 30, 1897	50,000
Year ending June 30, 1898	50,000
Year ending June 30, 1899	50,000
Year ending June 30, 1900	50,000
Year ending June 30, 1901	100,000
Year ending June 30, 1902	100,000
Year ending June 30, 1903	200,000
Year ending June 30, 1904	200,000
Year ending June 30, 1905	200,000
Year ending June 30, 1906	200,000

The chief feature of the work of the hydrographic division is the systematic study of the flow of the surface waters and the conditions

affecting the same. In this connection other information that may be of use to the engineer or others in hydrographic studies, such as river profiles, duration and extent of damage by floods, water-power data, etc., is collected. Furthermore, the work has been so directed that the information collected will be of direct value in the commercial and agricultural development of the country.

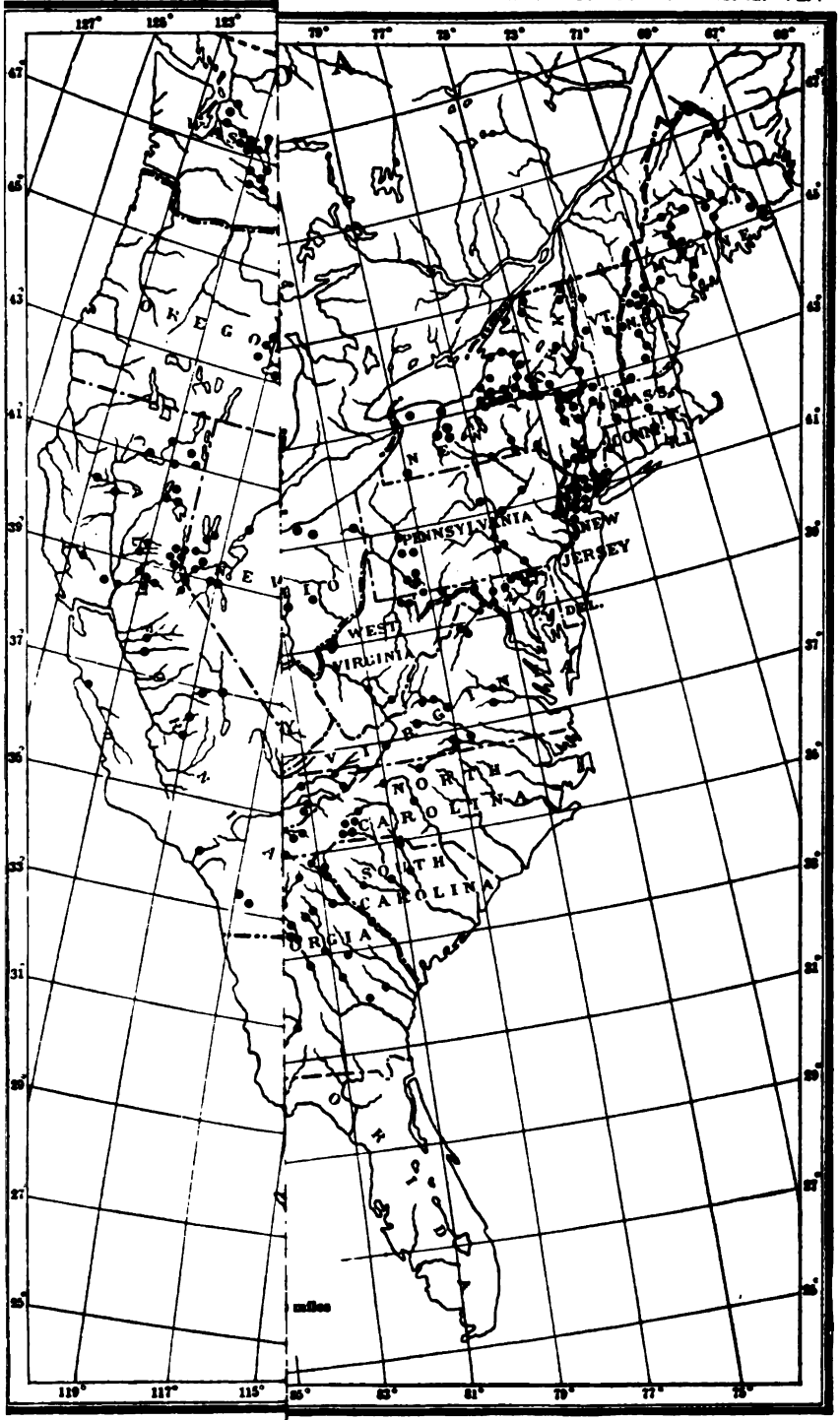
As a result of the increased appropriations since June 30, 1902, the work has been largely extended and thoroughly systemized. The various States have been grouped into districts, each of which is under the supervision of a district hydrographer who, with a corps of assistants, devotes his whole time to the study of the hydrographic resources of his district.

The methods used in the collection of these data and in their preparation for publication are given in detail in Water-Supply Paper No. 94. (Hydrographic Manual, U. S. Geol. Survey.)

The general plan of stream gaging which has been developed is to obtain eventually data in regard to the flow of all the important streams in the United States. With this in view gaging stations are established at points where the data will be of greatest commercial value. At these stations discharge measurements are taken from time to time at typical river stages, and the daily surface fluctuation is obtained by means of gage readings. From these two factors it is possible to estimate both the total flow and its distribution through the period of observation.

The selection of the site for a gaging station and the length of time the station is maintained depend largely upon the needs of each locality. If the stream is to be used for water power, special efforts are made to obtain information concerning the low-water flow. If water is to be stored, the high waters are given special attention. In all sections certain permanent stations are maintained for general statistical purposes to show the conditions which exist through long periods. They also act as primary stations, and are used in connection with short series of measurements to determine the flow in particular portions of the drainage basin.

Gaging stations are divided into two general classes: First, current-meter stations, and, second, weir stations. The former class is subdivided as to location into bridge, cable, boat, and wading stations. Fig. 1 shows a cable station with car, tag line, inclined gage, etc. In addition to the bridge, cable, or boat, the equipment of a current-meter gaging station consists in a gage for determining the daily fluctuations of the water surface, bench marks to which the zero of the gage is referred, and permanent marks on the bridge or a tagged line indicating the points of measurement. Where the current is swift some appliance, generally a secondary cable, is necessary to hold the meter below the surface.



MAINED DURING 1904.

Gaging stations are generally located at bridges, if the channel conditions are satisfactory, as from them the meter can be easily manipulated and the cost of the equipment is comparatively small. The stations are located as far as possible at points where the channel is straight, both above and below the gaging section, and where there are no cross currents, backwater, or boils. The bed of the stream should be as clear as possible from large projections and of a permanent character. The banks should be high, and should overflow at high stages only. At stations with shifting beds more measurements are made, and special methods of computing daily discharges are employed. Great care is taken in the selection and equipment of gaging stations, in order that the data may have the required degree of accuracy.

On many of the larger rivers, where water power is developed by dams, estimates of flow are obtained by observing the head on the crest and using a weir formula. On the smaller streams sharp-crested weirs are in some cases erected.

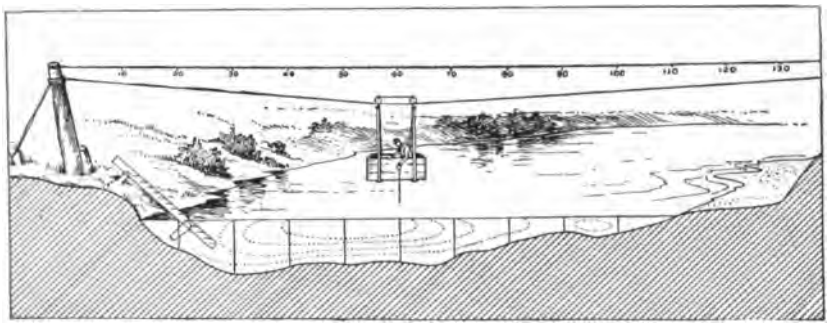


FIG. 1.—Cable station, showing section of river, car, gage, etc.

The principal instrument used in stream-measurement work is the current meter, by which the velocity of the flow of water is determined. After years of experience the Survey has adopted the Price current meter for general work. This meter, as is shown on Pl. II, is made in two sizes, known as the large and small Price. The small Price has been largely developed by the officers of the Survey, using the Price acoustic meter as a basis.

A discharge measurement is the determination of the quantity of water flowing past a certain point at a given time. This quantity is the product of two factors: (1) The mean velocity, which is the function of the cross section, surface, slope, wetted perimeter, and roughness of bed; (2) the area, which depends upon the permanency of the bed and the fluctuations of the surface, which govern the depth.

In making the measurement an arbitrary number of points are laid off perpendicular to the thread of the stream (see fig. 1). These points are usually at regular intervals varying from 2 to 20 feet, depending

upon the size and conditions of the stream. They are known as measuring points, and at them the observed data, the velocities and soundings, are taken. The perpendiculars dropped from the measuring points divide the gaging section into strips, and for each strip or pair of strips the mean velocity, area, and discharge are determined independently; thus conditions existing in one part of the stream are not distributed to parts where they do not apply.

The methods of obtaining velocity with the current meters which are in general use may be grouped into three classes: Single point, multiple point, and integration.

The single-point method consists in holding the meter either at the depth of the thread of mean velocity or at an arbitrary depth for which the coefficient for reducing to mean velocity has been determined. Extensive experiments by vertical velocity-curves show that the thread of mean velocity lies at from 0.5 to 0.7 of the total depth. In general practice the thread of mean velocity is considered to be at 0.6 depth, and it is at this depth that the meter is held in the majority of the measurements, this being known as the six-tenths depth method. It is found by a large number of vertical velocity-curve measurements, taken on various streams and under various conditions, that the coefficient for reducing the velocity obtained at sixth-tenths depth to mean velocity is practically unity, ranging, in a series of 910 measurements made at 39 gaging stations, between 0.94 and 1.04, with a mean for the 910 observations of 1.00. In the other principal single-point method the meter is held near the surface, usually 1 foot below, or low enough to be out of the action of the wind or other disturbing influences. This is known as the subsurface method. The coefficient for reducing the velocities taken at the subsurface has been found by repeated experiments with vertical velocity-curves to be from 0.85 to 0.95, depending upon the depth of the stream and velocity and channel conditions. This method is specially adapted for flood measurements or when the velocity is so great that the meter can not be kept at 0.6 depth.

The three principal multiple-point methods in general use are: The vertical velocity curve; top and bottom; and top, bottom, and mid depth. In the vertical velocity-curve method a series of velocity determinations are taken in the vertical at regular intervals, usually from 0.5 to 1 foot apart. By platting these velocities as abscissas and their depths as ordinates, and drawing a smooth curve through these points, the vertical velocity-curve is produced, which shows the change in velocity from the surface to the bottom of the stream. The mean velocity in the vertical is then obtained by dividing the depth into the area bounded by this mean velocity curve and the initial line. Owing to the length of time it takes to make these measurements, they are seldom used except for determining coefficients for purposes of comparison and for measurements under ice.

PRICE CURRENT METERS, WITH BUZZERS.

In the second multiple-point method the meter is held from 0.5 to 1 foot below the surface and about 0.5 foot above the bottom, and the mean of the velocities at these two points is taken as the mean velocity for that vertical. This method is not well adapted for general work, as the roughness of the bottom disturbs the velocity at that point. For shallow streams with comparatively smooth beds good results are obtained by this method. In the third multiple-point method the meter is held at mid depth, 0.5 foot below the surface, and 0.5 foot above the bottom, and the mean velocity is determined by dividing the sum of the top velocity, twice the mid-depth velocity, and the bottom velocity by 4.

The vertical-integration method consists in moving the meter at a slow, uniform speed from the surface to the bottom and back again to the surface. The number of revolutions and the time taken in the operation is noted, and the mean velocity is found by dividing the number of revolutions by the number of seconds taken in the run. This method has the advantage in that the velocity at each point of the vertical is measured twice. It is well adapted for measurements under ice and as a check on the point methods.

The area, which is the other factor for determining the discharge of the stream, depends upon the stage of the river, which is taken on a gage, and the general contour of the bed of the stream, which is found by sounding. The soundings are usually taken at each measuring point at the time of the discharge measurement, either by using the meter and cable or by a special sounding line or rod. For stations with permanent beds standard cross sections are usually taken during low water. These sections serve to check the soundings which are taken at the time of the measurements, and from them any change which may have taken place in the bed of the stream can be detected. They are also used for obtaining the area for use in high-water measurement computations, as accurate soundings are hard to obtain at high stages.

In computing the discharge measurements from the observed velocities and depths at the various points of measurements the measuring section is divided into elementary strips, as shown in fig. 1, and the mean velocity, area, and discharge are determined separately for either a single or double strip. The total discharge and area are the sums of those for the various strips, and the mean velocity is obtained by dividing the total discharge by the total area.

The volume of water flowing in a stream is known as run-off. In expressing it various units are used, depending upon the kind of work for which the data are needed. Those used in this report are "second-feet," "acre-feet," "run-off per square mile," and "run-off in depth in inches," and may be defined as follows:

"Second-foot" is an abbreviation for cubic foot per second, and is the body of water flowing in a stream 1 foot wide, 1 foot deep, at a rate of 1 foot per second.

The "acre-foot" is the unit of capacity used in connection with storage for irrigation work, and is equivalent to 43,560 cubic feet. It is the quantity required to cover an acre to a depth of 1 foot. There is a convenient relation between the second-foot and the acre-foot: 1 second-foot flowing for twenty-four hours will deliver 86,400 cubic feet, which equals 1.9835 acre-feet, or, approximately, 2 acre-feet.

The expression "second-feet per square mile" means the average number of cubic feet of water flowing each second from every square mile of drainage area, on the assumption that the run-off is uniformly distributed.

"Depth in inches" means the depth of water in inches that would have covered the drainage area, uniformly distributed, if all the water could have accumulated on the surface. This quantity is used for comparing run-off with rainfall, which quantity is usually given in depth in inches.

It should be noticed that "acre-feet" and "depth in inches" represent the actual quantities of water which are produced during the periods in question, while "second-feet," on the contrary, is merely a rate of flow per second.

The base data for computing the daily discharge of a stream are the daily gage heights and the various discharge measurements, of which there should be sufficient number to cover the range of stage. The fundamental laws upon which these computations are based are the following:

(1) The discharge will remain constant so long as the conditions at or near the gaging station remain constant;

(2) Neglecting the change of slope due to the rise and fall of the stream, the discharge will be the same whenever the stream is at a given stage; and

(3) The discharge is both a function of, and increases gradually with, the gage heights. (2 and 3 depend on 1.)

As the beds of many streams are changeable, the problem divides itself into two classes: (1) Those of streams with permanent, or practically permanent, beds, and (2) those of streams with changeable beds. The base data and methods of obtaining them are the same for either class, and it is only in the computation of the mean daily flow that different methods are necessary.

In determining the daily discharge of streams with permanent beds the results of the discharge measurements are plotted on cross-section paper, with gage heights as ordinates and discharges as abscissas. Through these points a smooth curve is drawn, which shows the discharge for any gage height, and from which a rating table is prepared. Aside from plotting the discharge, the mean velocity and area determined for each discharge measurement are plotted. Through these points the curves of mean velocity and of area are drawn, and the rating curve is largely determined by taking the product of the mean

velocity and the area at various stages as determined by these curves. These curves of mean velocity and area are of special value to determine the location of the rating curve for stages at which actual discharge measurements are not available and for extending the discharge curve outside the limits of the measurements. In the preparation of the rating table the discharge for each tenth or half tenth on the gage is found from the curve. The first and second differences of these discharges are then taken and adjusted according to the law that they shall either be constant or increasing, never decreasing. The discharges in the table are then changed in accordance with these adjusted differences. In making up the station-rating curve the individual discharge measurements and the conditions under which they were taken are carefully studied, in order that proper weight shall be given to each measurement. Rating curves in general take the form of a parabola, and as a rule the high-water portion of the curve approaches a straight line. For stations of permanent character the results of the measurements from year to year should be within 5 per cent of the curve, with the exception of those taken during high water, when the probable error may be as high as 10 per cent.

The determination of the daily discharge of streams with changeable beds is difficult, and unless frequent discharge measurements are made the results obtained are only roughly approximate. For streams with continually shifting beds, such as Colorado River and the Rio Grande, discharge measurements are made every two or three days, and the discharges for the intervening days are obtained by interpolation, modified by the gage heights for these days. For stations with beds which shift slowly, or are only materially changed during floods, station-rating curves and tables can be prepared for the periods between changes, and satisfactory results can be obtained with two or three measurements a month, providing measurements are taken soon after the changes take place.

In determining the flow for periods when the streams are frozen, special rating curves and tables have to be prepared from measurements taken under these conditions. The methods of constructing these curves and tables are the same as for open sections. The discharge measurements, however, are either taken by integration in verticals or by the vertical velocity-curve method, as sufficient experiments have not been made on ice-covered streams to determine the laws which govern the position of the thread of mean velocity.

The Report of Progress of Stream Measurements for the Calendar Year 1904, of which this is Part IV, is published in a series of twelve Water-Supply Papers, Nos. 124–135, inclusive, under the following subtitles:

Part 1. Atlantic coast of New England drainage.
Part 2. Hudson, Passaic, Raritan, and Delaware River drainages.

Part 3. Susquehanna, Patapsco, Potomac, James, Roanoke, Cape Fear, and Yadkin River drainages.

Part 4. Santee, Savannah, Ogeechee, and Altamaha rivers and Eastern Gulf of Mexico drainage.

Part 5. Eastern Mississippi River drainage.

Part 6. Great Lakes and St. Lawrence River drainage.

Part 7. Hudson Bay, Minnesota, Wapsipinicon, Iowa, Des Moines, and Missouri River drainages.

Part 8. Platte, Kansas, Meremac, Arkansas, and Red River drainages.

Part 9. Western Gulf of Mexico drainage.

Part 10. Colorado River and Great Basin drainage.

Part 11. The Great Basin and Pacific Ocean drainage in California.

Part 12. Columbia River and Puget Sound drainage.

The territory covered by each paper is given in the subtitle, and the larger drainages are, for convenience in arrangement, subdivided into smaller ones, under which the data are arranged, as far as practicable, geographically.

These papers contain the data that have been collected at the regular gaging stations, the results of the computations based upon the observations and such other information that has been collected that has a direct bearing on these data including, as far as practicable, descriptions of the drainage areas and the streams draining them.

For each regular station are given, as far as available, the following data:

1. Description of station.
2. List of discharge measurements.
3. Gage-height table.
4. Rating table.
5. Table of estimated monthly and yearly discharges and run-off.

The descriptions of stations give, as far as possible, such general facts about the locality and equipment as would enable the reader to find the station and use the same. They also give, as far as possible, a complete history of all the changes that have occurred since the establishment of the station that would be factors in using the data collected.

The discharge-measurement table gives the results of the discharge measurements made during the year. This includes the date, the hydrographer's name, the gage height, and the discharge in second-feet.

The table of daily gage heights gives for each day the mean height of the surface of the river as found from the mean of the gage readings taken on that day. At most of the stations the gage is read in the morning and in the evening.

The rating table gives discharges in second-feet corresponding to each stage of the river as given by the gage heights.

In the table of estimated run-off the column headed "Maximum" gives the mean flow for the day when the mean gage height was the

highest, and it is the flow as given in the rating table for that mean gage height. As the gage height is the mean for the day, there might have been short periods when the water was higher and the corresponding discharge larger than given in this column. Likewise in the column of "Minimum" the quantity given is the mean flow for the day when the mean gage height was lowest. The column headed "Mean" gives the average flow for each second during the month. Upon this mean the computations for the three remaining columns which are defined on pages 11 and 12 are based.

In the computations for the tables of this report the following general and special rules have been used:

Fundamental rules for computation.

1. The highest degree of precision consistent with the rational use of time and money is imperative.

2. All items of computation should in general be expressed by at least two and by not more than four significant figures.

3. Any measurement in a vertical velocity, mean velocity, or discharge curve whose per cent of error is 5 times the average per cent error of all the other measurements should be rejected.

4. In reducing the number of significant figures, or the number of decimal places, by dropping the last figure, the following rules apply:

(a) When the figure in the place to be rejected is less than 5, drop it without changing the preceding figure. Example: 1,827.4 becomes 1,827.

(b) When the figure in the place to be rejected is greater than 5, drop it and increase the preceding figure by 1. Example: 1,827.6 becomes 1,828.

(c) When the figure in the place to be rejected is 5, and it is preceded by an even figure, drop the 5. Example: 1,828.5 becomes 1,828.

(d) When the figure in the place to be rejected is 5, and it is preceded by an odd figure, drop the 5 and increase the preceding figure by 1. Example: 1,827.5 becomes 1,828.

5. In constructing and applying rating tables a maximum limit of one-half per cent error should seldom be exceeded.

Special rules for computation.

1. Rating tables are to be constructed as close as the data upon which they are based will warrant. No decimals are to be used when the discharge is over 50 second-feet.

2. Daily discharges shall be applied directly to the gage heights as they are tabulated.

3. Monthly means are to be carried out to one decimal place when the quantities are below 100 second-feet. Between 100 and 10,000 second-feet, the last figure in the monthly mean shall be a significant figure. This also applies to the yearly mean.

4. Second-feet per square mile and depth in inches for the individual months shall be carried out at least to three significant figures, except in the case of decimals, where the first significant figure is preceded by one or more "0," when the quantity shall be carried out to two significant figures. Example: 1.25; .125; .012; .0012. The yearly means for these quantities are always to be expressed in three significant figures and at least two decimal places.

The results of the stream measurements made during previous years by the United States Geological Survey can be found in the following Survey publications. A detailed index of the reports for years previous to 1904 is given in Water-Supply Paper No. 119.

1888. Tenth Annual Report, Part II.
1889. Eleventh Annual Report, Part II.
1890. Twelfth Annual Report, Part II.
1891. Thirteenth Annual Report, Part III.
1892. Fourteenth Annual Report, Part II.
1893. Bulletin No. 131.
1894. Bulletin No. 131; Sixteenth Annual Report, Part II.
1895. Bulletin No. 140.
1896. Water-Supply Paper No. 11; Eighteenth Annual Report, Part IV.
1897. Water-Supply Papers Nos. 15 and 16; Nineteenth Annual Report, Part IV.
1898. Water-Supply Papers Nos. 27 and 28; Twentieth Annual Report, Part IV.
1899. Water-Supply Papers Nos. 35 to 39, inclusive; Twenty-first Annual Report, Part IV.
1900. Water-Supply Papers Nos. 47 to 52, inclusive; Twenty-second Annual Report, Part IV.
1901. East of Mississippi River, Water-Supply Papers Nos. 65 and 75.
West of Mississippi River, Water-Supply Papers Nos. 66 and 75.
1902. East of Mississippi River, Water-Supply Papers Nos. 82 and 83.
West of Mississippi River, Water-Supply Papers Nos. 84 and 85.
1903. East of Mississippi River, Water-Supply Papers Nos. 97 and 98.
West of Mississippi River, Water-Supply Papers Nos. 99 and 100.
1904. East of Mississippi River, Water-Supply Papers Nos. 124 to 129, inclusive.
West of Mississippi River, Water-Supply Papers Nos. 130 to 135, inclusive.

A limited number of these are for free distribution, and as long as the supply lasts they may be obtained by application to the Director United States Geological Survey or to members of Congress. Other copies are filed with the Superintendent of Public Documents, Washington, D. C., from whom they may be had at prices slightly above cost. Copies of Government publications are, as a rule, furnished to the public libraries in our large cities, where they may be consulted by those interested.

COOPERATION AND ACKNOWLEDGMENTS.

Most of the measurements presented in this paper have been obtained through local hydrographers. Acknowledgment is extended to other persons and corporations who have assisted local hydrographers or have cooperated in any way, either by furnishing records of the height of water or by assisting in transportation.

The following list, arranged alphabetically by States, gives the names of the resident hydrographers and others who have assisted in furnishing and preparing the data contained in this report:

Alabama.—District hydrographer, M. R. Hall,[a] assisted by J. M. Giles, W. E. Hall, and B. S. Drane. Dr. E. A. Smith, State geologist, has paid the salaries of river observers at Beck, Pera, Sturdevant, Jenifer, Riverside, Nottingham, Elk, and Centerville. Gage heights were furnished by the Corps of Engineers, U. S. Army, for Palos, Cordova, and Tuscaloosa, and by the United States Weather Bureau observer, F. P. Chaffee, for Selma and Montgomery.

Georgia.—District hydrographer, M. R. Hall, assisted by J. M. Giles, W. E. Hall, B. S. Drane, F. A. Murray, and O. P. Hall. Prof. W. S. Yeates, State geologist, has paid the salaries of river observers at Tallulah Falls, Groveland, Davisboro, Reidsville, Milledgeville (part of year), Greensboro, Buckhead, Flovilla, Lithonia, Covington, Norcross, Demorest, Freemans, Cantons, Carters, and Cartecay. J. M. Youngblood has furnished, without cost, gage heights for Augusta. The following United States Weather Bureau officials have furnished gage heights for the United States Weather Bureau stations, as noted in the description of stations: D. Fisher, Augusta, Ga.; J. B. Marbury, Atlanta, Ga.; and J. R. Weeks, Macon, Ga. Transportation has been furnished by J. S. B. Thompson, general agent of the Southern Railway; by E. Berkley, superintendent of the third division of the Seaboard Air Line Railway; by Thomas K. Scott, general manager of the Georgia Railroad; by James T. Wright, vice-president and general manager of the Macon, Dublin and Savannah Railroad; by J. H. Ellis, vice-president and general manager of the Atlanta, Knoxville and Northern Railway; by C. A. Wickersham, president and general manager, Atlanta and West Point Railway and Western Railway of Alabama; by W. L. Mapother, assistant to president of Louisville Railroad. The above transportation was not confined to the State of Georgia, but was also furnished for the States of South Carolina, Alabama, Mississippi, and Tennessee.

Mississippi.—District hydrographer, M. R. Hall, assisted by J. M. Giles and W. E. Hall. Gage heights were furnished by the United States Weather Bureau officials for the stations at Yazoo City and Columbus.

North Carolina.—District hydrographer, M. R. Hall, assisted by J. M. Giles, B. S. Drane, and O. P. Hall. Dr. C. A. Schenck, director of the Biltmore School of Forestry, paid the gage readers at Davidsons River, Sitton, and Pinkbed.

South Carolina.—District hydrographer, M. R. Hall, assisted by J. M. Giles, W. E. Hall, B. S. Drane, and F. A. Murray.

SANTEE RIVER DRAINAGE BASIN.

Santee River is formed in the central part of South Carolina by the junction of Congaree and Wateree rivers, flows southeast, and enters the Atlantic Ocean about 10 miles north of Cape Romain. It has a total length of about 180 miles (following the course of the river) and drains an area of about 15,000 square miles. It is a navigable stream for its entire length, and of course offers no opportunities for the development of power.

Wateree River, the more northerly of the two parent streams, rises on the eastern slope of the Blue Ridge, in McDowell County, N. C., and flows first northeast and then east, then bends abruptly southeast and flows in this general direction across the south-central portion of North Carolina and across the north-central part of South Carolina to its junction with the Congaree, practically paralleling the course of Yadkin and Pedee rivers. This stream, throughout its course in North Carolina, and also through that part of its course in South Carolina above the mouth of Wateree Creek, is known as Catawba River.

[a] Office of district hydrographer for South Atlantic States, 409 Temple Court, Atlanta, Ga.

The total length of the stream is about 270 miles in a straight line, and about 450 miles when all the windings are followed.

The Wateree is navigable as far as Camden, but above that point the fall is so great that navigation is impracticable. In 1826 and following years the State of South Carolina spent large sums in the attempt to render the river navigable by means of locks and dams. Some large and important works were constructed at great expense, but the undertaking was abandoned before their completion.

The drainage basin resembles that of the Yadkin in many respects, the upper portion of the stream flowing between parallel ranges of mountains, from which it receives many tributaries, affording much power. The average width of the valley of the main stream in North Carolina is only from 15 to 20 miles, and the fall in the main stream is considerable. The greater part of the drainage basin is hilly, and the upper portions are mountainous. A number of the tributary streams rise and flow for almost their entire length in high mountains. About 65 per cent of the upper part of the basin is in forest. Linville and John rivers, the principal tributaries in North Carolina, flow in country of this character, and their basins are almost entirely forested.

Wateree River crosses the fall line about 5 miles above Camden, S. C., in rapids about 5 miles in length, with a total fall of about 32 feet. The Great Falls of the Catawba are some distance above. This is the largest power in South Carolina, and one of the largest in the Southern States, the available fall being 173 feet.

The average rainfall in the basin is about 50 inches, the annual total increasing as the stream is ascended. The greatest flood ever experienced on the river was in May, 1901, the gage reading at the Rockhill station being 24.15 feet, and the measured discharge nearly 151,000 second-feet, or nearly 50 second-feet per square mile from the drainage basin above the station. The greatest flood previously experienced on the stream was in 1865. This was only about 2 feet lower than the flood of May, 1901, on the lower part of the river, but the May rise exceeded all previous records on the upper portion of the river by from 8 to 15 feet.

The minimum flow recorded for the Rockhill station is 1,300 second-feet, or about 0.43 second-foot per square mile. This occurred in September, 1895 and 1896. The maximum flow is about 116 times the minimum. During 1904 the minimum flow was 810 second-feet at the Catawba station. This was due to the storing of water at the new dam near Rockhill.

The Congaree, the second and more southerly of the two streams which by their union form the Santee, is formed by the junction of Broad and Saluda rivers between Lexington and Richland counties, S. C., whence it flows in a general southeasterly direction, but in a very

tortuous channel, for about 60 miles to its junction with the Wateree. The stream is navigable to Columbia, the capital of the State. There it crosses the fall line, giving rise to a very fine water power, the only one on the stream, which is being extensively used in the manufacturing enterprises of Columbia.

Broad River rises on the eastern slope of the Blue Ridge near Hickory Nut Gap, in the southwestern part of McDowell County and the northeastern part of Henderson County, N. C., and flows in a general southeasterly direction across a portion of south-central North Carolina and north-central South Carolina to its junction with the Saluda at Columbia. The length of the river in a straight line is about 128 miles, but it is much greater if the course of the river is followed.

In general character the drainage basin closely resembles those of the Yadkin and the Catawba. It lies entirely above the fall line, is without lakes, and is well wooded, especially in the upper portion, and the soil is generally loose and porous.

The rainfall of the basin averages about 51 inches, of which about 13 inches fall in spring, the same in summer, about 10 in autumn, and about 15 in winter. It is probable that the precipitation in the region about the headwaters is much greater than these amounts indicate.

The maximum flood recorded at the Alston station on this stream, 25 miles above Columbia, occurred in May, 1901, the estimated discharge being 131,000 second-feet, equivalent to about 28 second-feet per square mile. The minimum flow recorded at the same place is 1,250 second-feet, equivalent to 0.27 second-foot per square mile. This occurred during October, 1904. The maximum flow is therefore about 105 times the minimum.

Saluda River is formed in western South Carolina by the junction of the North, South, and Middle forks, and flows southeast to its junction with Broad River, the length of the stream being about 110 miles in a straight line. The three forks are mountain streams, and the character of the drainage basin is similar to that of Broad River.

The average rainfall over the basin of the stream is 51 inches, the amount and seasonal distribution being similar to that on the Broad. The maximum flood recorded at the Waterloo station on this stream occurred in February, 1902, the rise being 23 feet above low water, and the estimated discharge being about 18,500 second-feet, equivalent to about 18 second-feet per square mile. The minimum discharge so far recorded is 200 second-feet, or about 0.19 second-foot per square mile. This occurred during October, 1904. The maximum discharge is therefore about 108 times the minimum.

The following pages give the results of the data collected in this drainage during 1904.

CATAWBA RIVER NEAR CATAWBA, S. C.

This station was established in order to continue the records on Catawba River after the Rockhill station had been abandoned. No very favorable section was found, but this one was selected as the most available one, and a temporary gage was put in by J. M. Giles on September 11, 1903, in order to start the gage-height records.

The station is located at the bridge of the Southern Railway, 2 miles southeast of Catawba, S. C., and about 2 miles below the crossing of the Seaboard Air Line Railway. The deck bridge, from which measurements are made, is a three-span wooden-lattice structure about 520 feet long, with 250 feet of trestle approach on right bank and 160 feet on the left bank. At ordinary stages the river is about 490 feet wide: at high stages the banks, which are rather high, will overflow to some extent, but all water will pass under the bridge and its approaches. The bed is partly rock and will probably shift little. The channel is straight above and below the bridge. The current is sluggish at low water—rather too much so for accurate work. The bridge is not quite at right angles with the current and corrections are made to the widths in computing measurements.

The measurements are made from a plank footway on the lower members of the bridge. The initial point for soundings is the river edge of the capstone on the left bank pier. The gage is a vertical 1 by 4 inch timber, reading from zero to 12 feet, and consists of two 5-foot sections and a 2-foot section fastened to a 3 by 10 inch timber, which is driven into the bed of the river and spiked to a willow tree. It is located on the left bank of the river, about 85 feet above the bridge. A second section of gage is attached to a tree on bank of small branch, about 200 feet from river, and the same distance above the bridge. This section extends from 12 to 27 feet.

Bench mark No. 1 is the top of the joint plate on the upstream bottom chord, at a point 44 feet from the initial point. Its elevation is 31.70 feet above the zero of the gage. Bench mark No. 2 is a standard copper plug set in a solid rock projecting from water in river about 200 feet above the bridge, and opposite point 240 feet from initial point. Its elevation is 5.73 feet above the zero of the gage.

The observer is J. Y. Brice, who is conveniently located at the railroad pump house near by. During 1904 the gage was read twice each day.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Catawba River near Catawba, S. C., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
August 10	J. M. Giles	385	2,682	0.93	2.52	2,506
September 11	do	389	2,989	1.32	3.02	3,944
October 23	do	378	2,646	.85	2.30	2,253
December 11	do	375	2,649	.78	2.40	2,057
1904.						
March 7	J. M. Giles	392	3,641	1.76	4.00	6,421
March 8[a]	do	356	3,855	5.22	8.20	20,130
March 9[a]	do	355	3,887	4.53	7.85	17,610
March 21	do	379	3,086	.95	2.75	2,943
May 7	do	393	3,291	1.00	2.90	3,279
July 25	do	415	3,348	1.14	2.98	3,806
September 12	do	426	3,036	.33	1.65	1,016
November 21	do	436	3,345	.58	2.22	1,926

[a] Taken at Seaboard Air Line Railway bridge.

Mean daily gage height, in feet, of Catawba River near Catawba, S. C., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.40	3.00	3.50	2.75	2.50	2.50	5.50	3.35	2.90	1.80	1.85	1.95
2	2.30	3.20	3.30	2.75	2.45	5.40	3.65	4.00	3.30	[a]1.40	1.85	2.15
3	2.30	2.30	3.10	2.60	2.35	4.20	3.00	4.70	4.00	[a]1.65	1.80	2.45
4	2.30	2.30	3.30	2.65	2.45	3.70	2.65	3.70	3.25	1.85	2.15	2.55
5	2.30	2.30	3.00	2.60	2.80	3.05	2.50	3.40	4.05	1.75	3.15	2.70
6	2.20	2.30	3.00	2.65	3.35	2.85	2.35	4.60	5.40	1.65	2.45	5.05
7	2.10	2.50	4.20	2.60	2.95	3.20	2.30	4.05	3.65	1.70	2.85	4.65
8	2.20	2.90	7.30	2.60	2.80	3.70	2.35	10.05	2.80	1.75	2.45	3.65
9	2.40	3.50	7.40	2.70	2.80	2.90	2.25	6.55	2.45	1.80	2.15	3.00
10	2.40	3.30	5.00	2.80	3.35	2.65	2.35	5.40	2.65	1.95	2.05	2.70
11	2.40	3.20	4.00	3.20	4.70	2.50	2.40	4.95	3.85	1.90	2.00	2.50
12	2.30	3.00	3.60	2.95	3.85	2.65	2.35	7.50	1.70	1.85	1.90	2.60
13	2.30	2.20	3.30	2.75	3.30	2.70	2.90	5.75	2.30	1.80	3.00	2.40
14	2.20	2.50	3.30	2.65	3.00	2.45	2.70	3.75	2.15	1.75	4.90	2.25
15	2.00	2.50	3.60	2.55	3.10	2.35	2.20	3.05	2.20	1.70	4.05	2.30
16	2.10	2.90	3.20	2.60	3.30	2.25	2.10	4.70	2.15	1.70	3.05	2.20
17	2.30	2.30	2.95	2.60	2.90	2.20	2.10	5.10	2.20	1.85	2.60	2.25
18	2.20	2.30	2.95	2.55	2.75	2.20	2.35	3.00	2.10	1.80	2.30	2.35
19	2.20	2.40	2.90	2.55	2.70	2.40	2.05	2.65	2.15	1.75	2.15	2.50
20	2.40	3.40	2.75	2.45	3.15	2.55	2.05	2.55	1.95	[a]1.65	2.20	2.35
21	2.40	3.90	2.75	2.50	3.00	2.50	1.95	2.90	2.10	1.70	2.35	2.25
22	2.60	6.80	2.70	2.50	2.75	2.50	2.35	2.60	1.95	1.75	2.15	2.25
23	3.60	7.00	2.90	2.50	2.55	2.40	2.85	2.55	1.95	1.75	2.10	2.25
24	3.90	5.30	3.55	2.60	2.40	2.25	2.90	2.50	2.00	1.85	2.15	2.05
25	3.00	4.00	3.40	2.50	2.35	2.20	2.95	3.30	1.85	1.70	2.30	2.35
26	3.00	3.50	3.35	2.50	2.40	2.05	2.40	4.20	1.95	1.85	2.15	2.30
27	1.50	3.50	3.35	2.70	2.35	2.10	2.65	5.85	2.20	1.95	2.15	2.60
28	2.60	4.10	3.35	2.65	2.30	2.10	2.95	6.60	2.00	1.75	2.15	2.90
29	2.00	3.60	3.05	2.75	2.25	3.55	4.30	4.30	1.55	1.75	1.95	3.05
30	1.50	.....	2.95	2.55	2.20	6.35	4.05	2.90	1.60	1.80	1.95	3.15
31	2.40	.....	2.85	.....	2.35	.....	3.05	2.60	.....	1.85	.....	2.90

[a] Storing water at the new dam at Rock Hill, S. C., accounts for low days.

Rating table for Catawba River near Catawba, S. C., from September 11, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.40	810	2.10	1,655	2.80	3,200	3.50	5,205
1.50	900	2.20	1,825	2.90	3,470	3.60	5,500
1.60	1,000	2.30	2,015	3.00	3,750	3.70	5,800
1.70	1,110	2.40	2,225	3.10	4,035	3.80	6,100
1.80	1,230	2.50	2,450	3.20	4,325	3.90	6,400
1.90	1,360	2.60	2,690	3.30	4,615	4.00	6,700
2.00	1,500	2.70	2,940	3.40	4,910		

The above table is based upon 12 discharge measurements made during 1903–1904. It is well defined between gage heights 1.5 feet and 4.0 feet. Above 4.0 it is only fairly determined. The table has been extended beyond these limits. Above gage height 3.60 feet the rating curve is a tangent, the difference being 300 per tenth.

Estimated monthly discharge of Catawba River near Catawba, S. C., for 1903 and 1904.

[Drainage area, 1,514 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1903.					
September 11–30	16,300	1,825	3,962	2.62	1.95
October	4,910	1,825	2,313	1.53	1.76
November	6,400	2,015	2,754	1.82	2.03
December	3,470	2,015	2,269	1.50	1.73
1904.					
January	6,400	900	2,313	1.53	1.75
February	15,700	1,825	4,783	3.16	3.41
March	16,900	2,940	5,366	3.54	4.08
April	4,325	2,337	2,808	1.85	2.06
May	8,800	1,825	3,344	2.21	2.55
June	13,750	1,578	3,599	2.38	2.66
July	11,200	1,480	3,172	2.10	2.42
August	24,850	2,450	7,629	5.04	5.81
September	10,900	950	2,883	1.90	2.12
October	1,480	810	1,198	.791	.912
November	9,400	1,230	2,451	1.62	1.81
December	9,850	1,480	2,994	1.98	2.28
The year	24,850	810	3,545	2.34	31.87

CATAWBA RIVER NEAR MORGANTON, N. C.

The original station was established June 19, 1900, in connection with the hydrographic investigation of the Southern Appalachian area, at which time a wire gage was installed on the highway bridge on the road from Morganton to Hartland. In May, 1901, the river throughout this part of its course rose from 8 to 15 feet higher than ever before known, and the bridge and gage were destroyed. The present station was established May 15, 1903, by E. W. Myers, assisted by B. S. Drane, at the bridge which was built to replace the one carried away by the flood of May, 1901. The station is 1 mile north of Morganton and about 200 yards below the mouth of Upper Creek. The standard chain gage with inclosed scale is attached to the lower chord of the downstream side of the bridge. The zero of the scale is about 94 feet from the initial point for soundings. The length of the chain from the end of the weight to the marker is 36.95 feet. The gage is read once each day by Hort Edmunson. Discharge measurements are made from the downstream side of the single-span steel highway bridge to which the gage is attached. The initial point for soundings is the left end of the downstream hand rail. Distances are laid off along this rail and are marked in white paint. The channel is straight for about 200 feet above and for about 600 feet below the station. The current is swift. The right bank is low and overflows to a slight extent on account of erosion, but all water passes beneath the approach to the bridge. The left bank is high, rocky, and wooded. The bed of the stream is rocky, with sand and gravel near the right bank.

Bench mark No. 1 is the left side of the upper surface of the sixth floor beam at the downstream side of the bridge, 13 feet to the right of the zero of the gage. The point is indicated by a spot of white paint and the letters B. M. When the gage reads zero the water surface is 34.77 feet below this point. Bench mark No. 2 is a copper plug set in cement in a rock on the left bank 24.3 feet back of the initial point for soundings, and is 3 feet downstream from the line of the downstream truss. It is about 1½ feet above the road and is inclosed in a circle of white paint and marked "B. M." Its elevation is 37.37 feet above datum of the gage.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Catawba River near Morganton, N. C., in 1903 and 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
February 13	E. W. Myers	850	3.36	2.77	2,861
May 5	do	726	2.28	2.04	1,656
May 5	do	726	2.33	2.05	1,688
June 25	do	611	2.09	1.93	1,276
June 25	do	611	2.10	1.95	1,282
August 21	B. S. Drane	552	2.14	1.77	1,181
August 21	do	554	2.15	1.76	1,193
October 28	do	458	1.15	1.16	528
October 28	do	462	1.21	1.18	559
December 11	do	439	1.09	1.19	480
December 11	do	440	1.12	1.22	493
1904.					
February 17	B. S. Drane	435	1.24	1.23	539
March 18	do	622	1.31	1.56	816
March 18	do	615	1.37	1.56	843
May 5	do	641	2.04	2.08	1,305
May 27	do	458	1.68	1.48	770
July 21	do	415	1.08	1.01	447
August 19	do	427	1.49	1.28	637
September 29	do	356	1.10	1.04	391
September 29	do	356	1.11	1.01	395
December 15	do	394	1.15	1.15	454
December 16	do	405	1.23	1.18	500

Main daily gage height, in feet, of Catawba River near Morganton, N. C., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.25	1.30	1.80	1.55	1.35	4.45	1.95	3.10	1.70	0.95	1.00	1.10
2	1.25	1.30	1.65	1.50	1.35	3.25	1.70	2.35	2.20	.95	1.00	1.15
3	1.25	1.25	1.60	1.45	3.30	2.40	1.50	1.90	1.55	.95	1.10	1.25
4	1.20	1.25	1.55	1.40	2.60	2.10	1.35	1.70	1.90	.90	1.75	1.40
5	1.20	1.25	1.50	1.40	2.15	1.90	1.50	1.95	2.20	.95	1.50	1.70
6	1.20	1.25	1.50	1.40	1.80	1.75	1.35	2.30	1.50	.95	1.30	2.05
7	1.50	1.35	9.20	1.50	1.70	1.95	1.30	2.45	1.40	1.10	1.15	1.55
8	1.30	1.90	4.30	1.55	3.50	2.00	1.30	2.00	1.30	1.00	1.10	1.40
9	1.20	1.70	2.80	2.65	4.10	1.65	1.35	1.70	1.30	1.05	1.10	1.35
10	1.20	1.65	2.30	1.70	3.05	1.60	1.30	2.10	1.30	1.00	1.05	1.35
11	1.20	1.50	2.10	1.60	2.40	1.70	1.30	2.05	1.35	.95	1.00	1.35
12	1.20	1.40	1.90	1.60	2.10	1.55	1.35	2.40	1.30	.95	1.00	1.25
13	1.20	1.40	1.80	1.60	2.00	1.45	1.30	1.85	1.25	.90	1.80	1.25
14	1.20	1.35	1.80	1.55	1.95	1.45	1.25	1.65	1.20	.90	1.50	1.20
15	1.20	1.35	1.75	1.50	1.90	1.40	1.25	1.50	1.15	.95	1.35	1.15
16	1.20	1.35	1.65	1.45	1.70	1.45	1.20	1.50	1.10	.90	1.25	1.15
17	1.15	1.30	1.60	1.55	1.65	1.65	1.15	1.40	1.05	.85	1.20	1.20
18	1.15	1.30	1.60	1.45	2.30	1.60	1.10	1.35	1.05	.95	1.20	1.25
19	1.15	1.30	1.55	1.40	2.90	2.05	1.10	1.30	1.10	.90	1.10	1.20
20	1.15	1.30	1.50	1.35	1.80	1.80	1.05	1.40	1.10	.90	1.00	1.15
21	1.20	1.30	1.50	1.40	1.60	1.55	1.10	1.35	1.10	.90	1.05	1.15
22	1.25	2.80	1.60	1.40	1.60	1.45	1.10	1.40	1.05	.90	1.05	1.10
23	2.40	2.40	1.60	1.45	1.55	1.40	1.20	2.40	1.05	.90	1.05	1.05
24	1.65	1.85	1.90	1.35	1.60	1.35	1.15	2.40	1.05	.90	1.10	1.05
25	1.50	1.70	2.00	1.35	1.60	1.30	2.40	1.60	1.05	.95	1.00	1.25
26	1.40	1.60	1.90	1.60	1.70	1.30	1.70	1.50	1.05	1.00	1.05	1.30
27	1.40	1.80	1.85	1.60	1.45	1.40	1.30	2.00	1.05	.95	1.05	1.75
28	1.35	1.80	1.80	1.45	1.50	1.65	1.65	1.65	1.00	.95	1.05	2.05
29	1.35	1.80	1.70	1.40	1.55	1.85	1.50	1.40	1.00	1.00	1.10	1.55
30	1.35	.....	1.60	1.35	1.65	2.50	1.40	1.30	.96	.95	1.10	1.50
31	1.30	.....	1.55	.....	5.25	.....	1.35	1.40	.....	1.00	.....	1.45

Rating table for Catawba River near Morganton, N. C., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.80	252	1.40	702	2.00	1,460	2.60	2,610
.90	307	1.50	800	2.10	1,640	2.70	2,805
1.00	372	1.60	908	2.20	1,830	2.80	3,000
1.10	447	1.70	1,026	2.30	2,025	2.90	3,195
1.20	527	1.80	1,156	2.40	2,220	3.00	3,390
1.30	612	1.90	1,300	2.50	2,415		

The above table is based upon discharge measurements made during 1903 and 1904. It is well defined between gage heights 1 foot and 2 feet. Above 2 feet the direction of the tangent is determined by one measurement at 2.77 feet. The table has been extended beyond these limits. Above gage height 2.2 feet the rating curve is a tangent, the difference being 195 per tenth. Above 2 feet the estimates can be considered a very rough approximation. This table is the same as the 1903 table, with the exception of a very slight change below 1.3 feet gage.

Estimated monthly discharge of Catawba River near Morganton, N. C., for 1904.

[Drainage area, 758 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	2,220	487	643	0.848	0.97[illegible]
February	3,000	569	915	1.21	1.[illegible]0
March	15,480	800	1,759	2.32	2.6[illegible]
April	2,708	657	846	1.12	1.25
May	7,777	657	1,878	2.48	2.8[illegible]
June	6,217	612	1,333	1.76	1.9[illegible]
July	2,220	410	711	.938	1.0[illegible]
August	3,585	612	1,293	1.71	1.97
September	1,830	339	639	.843	.94[illegible]
October	447	280	338	.446	.514
November	1,156	372	515	.679	.75[illegible]
December	1,550	410	679	.896	1.03
The year	15,480	280	962	1.27	17.32

JOHN RIVER NEAR MORGANTON, N. C.

This station was established as a bench-mark station. It is located at the iron highway bridge on the Lenoir road, about 3 miles from Morganton, N. C. Discharge measurements are made from the downstream side of the single-span bridge. The initial point for soundings is the left end of the main span, downstream side, over the middle of the left pier. The channel is curved for about 300 feet above and straight for 500 feet below the station. The current is swift. Both banks are high, wooded, and not liable to overflow. The bed of the stream is rocky along the left bank, which is composed of rock, and sandy along the right bank. There is but one channel at all stages.

The bench mark is the upper edge of the end of a bar extending from the floor beam to a brace at the downstream end of the second floor beam from the left pier, 32 feet from the initial point for soundings. Its elevation is 30.00 feet above datum.

Discharge measurements of John River near Morganton, N. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
May 27	B. S. Drane	64	172	1.72	1.66	295
July 21	do	61	163	1.26	1.44	205
August 19	do	62	170	1.40	1.53	238
September 29	do	61	135	1.13	1.31	153
December 16	do	61	146	1.00	1.27	146

WATEREE RIVER NEAR CAMDEN, S. C.

Camden, S. C., is on the Wateree River, 45 miles above its mouth, and about 5 miles below the fall line. The drainage area above the station is 2,635 square miles.

A station has been maintained here by the United States Weather Bureau since 1891. The gage is at the toll bridge about 2 miles west of Camden. Measurements are made from this bridge, which consists of two iron spans, about 180 feet each, supported by tubular iron piers, and has short wooden approaches with brick abutments on both banks. The bridge keeper is also the river observer. The Weather Bureau gage is in three sections, the lower section being a timber fastened to a log near the right bank and about 15 feet above the bridge, and reading from 0 to 8 feet. The second is a timber fastened to an ash tree on right bank about 25 feet above the bridge, and reading up to 15 feet. The third section, 15 to 32 feet, is painted on the upstream cylindrical pier on right bank. Only the third section, painted on the iron pier, is in good condition. On August 12, 1904, a new chain gage was put in by M. R. Hall, set to accord with the pier gage. The gage is a 24-inch iron top box, with outside scale. It is located at the upstream end of a floor beam, 40 feet from the right bank pier, and is fastened to a short vertical timber resting on the floor beam, and clamped to the double rod hanger. The bottom of the box is about 3 feet above the bridge floor, and is 41.53 feet above gage datum. The length of the chain is 43.53 feet.

Discharge measurements are made from the downstream side of the bridge. The initial point for soundings is the edge of the right bank brick abutment. Both banks are high, but are liable to overflow at time of floods. Both are open and cultivated except along the bank where there are trees. The channel is 270 feet wide at low water, and is broken by one pier. The current is smooth and moderately swift, except at lowest stages. The bed is sand and is probably changing. The river below has a very small slope, which is unfavorable for good rating at high stages, as the position of flood crest will affect the slope largely.

Bench mark No. 1 is the top of the upstream end of the floor beam about 40 feet from right bank pier, at a point directly under the gage. Its elevation is 36.85 feet above the gage datum. Bench mark No. 2 is two large wire nails driven horizontally into a sycamore tree on right bank of river, and upstream side of the road, 110 feet from the pier. Its elevation is 31.27 feet above gage datum.

Discharge measurements of Wateree River near Camden, S. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
July 23	J. M. Giles	264	3,249	1.47	7.10	4,7[illegible]
August 11	M. R. Hall	324	6,627	1.97	17.80	13,0[illegible]
August 12	do	324	7,345	2.68	20.20	19,6[illegible]
September 13	J. M. Giles	270	2,215	.63	3.60	1,4[illegible]
September 14	do	271	2,538	.91	4.60	2,3[illegible]
November 19	do	274	2,538	.99	4.52	2,501

Mean daily gage height, in feet, of Wateree River near Camden, S. C., for 1904.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1	.....	3.00	3.20	3.70	17	4.60	.....	.....	4.50
2	.....	3.00	4.20	3.80	18	4.60	.....	.....	5.20
3	.....	3.30	4.00	4.90	19	4.00	.....	.....	5.10
4	.....	3.00	4.20	7.10	20	4.00	.....	.....	5.20
5	.....	3.30	5.80	5.50	21	4.00	.....	.....	4.20
6	.....	3.40	7.40	10.00	22	4.50	.....	.....	4.60
7	.....	3.40	5.10	14.10	23	3.90	3.50	.....	4.70
8	.....	3.20	6.20	11.10	24	4.00	3.40	.....	4.50
9	.....	3.30	5.20	8.10	25	4.10	3.00	.....	4.30
10	.....	3.50	4.70	6.50	26	3.90	3.50	.....	4.20
11	5.40	3.50	4.50	5.50	27	3.50	4.50	4.00	4.20
12	8.90	3.90	4.30	5.50	28	4.10	4.00	3.70	7.40
13	4.80	3.80	.....	5.00	29	4.20	4.00	3.70	8.50
14	4.80	3.80	.....	4.60	30	3.80	3.90	3.80	7.00
15	4.80	3.60	.....	4.50	31	.....	3.60	.....	6.40
16	4.80	.....	.....	4.60					

BROAD RIVER (OF THE CAROLINAS) AT ALSTON, S. C.

This station was established July 3, 1896, by E. W. Myers at the Southern Railroad bridge at Alston, S. C., about 27 miles above Columbia. The standard chain gage is located in the second span from the left end of the bridge. The zero of the scale is 74 feet from the initial point for soundings. The length of the chain from the end of the weight to the marker is 39.22 feet. The observer is G. M. Heron, a farmer of Alston, S. C., who reads the gage once each day. Discharge measurements are made from the downstream side of the steel through

6-span railway bridge to which the gage is attached. The initial point for soundings is the end of the second span nearest the left bank over the center of the pier. At flood stages some water passes behind this point. The channel above the station is straight, but the current is interrupted by a large island and passes under the bridge at an angle. Below the bridge the channel is straight for about one-half mile. Both banks are high and all water passes beneath the bridge. The bed of the stream is of sand and silt and is slightly shifting. There is but one channel at all stages.

Bench mark No. 1 is a point on the right side of the downstream end of the fifth floor beam from the left end of the second span from the left end of the bridge. It is marked in white paint and is indicated by the letters B. M. When the gage reads zero the water surface is 36.44 feet below this point. Bench mark No. 2 is a standard copper bolt set in rock on the left bank on the hillside 50 yards from the river and 52 feet downstream from the center line of the trestle approach to the bridge and is 21.2 feet from the corner of the pump house. The rock is white and the bench mark is under a small china tree. This bench mark is 9.85 feet below the bench mark on the bridge, making its elevation 26.59 feet above the gage datum.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Broad River (of the Carolinas) at Alston, S. C., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
March 23	E. W. Myers		12,300	5.78	19.85	71,140
April 17	E. C. Murphy		3,764	3.48	7.74	15,060
June 24	B. S. Drane		3,376	3.14	6.20	10,590
August 6	J. M. Giles		2,904	2.84	5.58	8,259
August 6	M. R. Hall		2,904	2.74	5.58	7,954
September 10	J. M. Giles		2,635	2.74	4.86	7,218
October 22	do		1,341	2.40	3.45	3,219
December 10	do		1,572	2.19	3.75	3,437
1904.						
January 27	W. E. Hall	519	1,809	2.28	4.10	4,128
March 3	J. M. Giles	528	1,835	2.61	4.50	4,786
May 6	do	521	1,757	2.20	4.18	3,861
July 22	do	521	1,847	2.42	4.10	4,465
September 15	do	429	1,255	1.65	2.95	2,065
November 18	do	489	1,524	1.85	3.55	2,817

Mean daily gage height, in feet, of Broad River (of the Carolinas) at Alston, S. C., 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.70	3.80	4.50	4.25	3.85	3.50	5.70	3.55	4.10	2.55	2.40	3.[illegible]
2	3.60	3.60	4.50	4.25	3.80	5.30	6.60	6.75	4.00	2.60	2.60	3.[illegible]
3	3.60	3.80	4.50	4.20	3.40	4.80	4.50	7.00	4.30	2.55	2.50	4.[illegible]
4	3.60	3.70	4.50	4.05	4.10	4.30	3.85	6.60	4.00	2.35	2.65	4.[illegible]
5	3.30	3.70	4.40	3.75	4.45	3.90	3.20	5.00	4.20	2.20	3.90	3.70
6	3.30	3.70	4.30	4.05	4.20	3.60	3.00	5.50	5.20	2.45	4.00	3.70
7	3.40	3.70	5.50	4.05	4.10	3.20	3.10	5.20	4.40	2.65	3.60	3.[illegible]
8	3.50	4.40	9.95	4.30	3.90	4.70	3.30	12.45	3.80	2.50	3.15	3.70
9	3.60	4.70	8.35	4.25	3.95	4.40	3.05	13.00	3.40	2.70	3.15	4.[illegible]
10	3.60	4.90	6.35	4.60	4.45	3.80	3.05	11.50	3.30	2.70	3.10	4.35
11	3.50	4.60	5.50	4.65	4.70	3.50	3.25	9.30	3.20	2.40	3.00	3.9[illegible]
12	3.40	4.40	5.10	4.05	4.20	3.40	3.30	8.70	3.10	2.55	3.00	3.35
13	3.60	4.20	4.90	4.10	3.95	4.40	4.10	7.30	2.80	2.55	3.50	3.60
14	3.60	4.10	4.90	4.10	3.85	3.50	3.30	5.20	2.85	2.65	6.10	3.70
15	3.60	3.90	4.70	4.00	3.80	3.45	3.05	4.55	3.00	2.65	5.60	3.70
16	3.50	3.80	5.00	3.95	4.05	3.20	2.75	7.50	2.85	2.40	4.45	3.75
17	3.60	4.00	4.55	4.00	4.00	3.20	3.40	5.90	2.65	2.50	3.80	3.70
18	3.50	3.90	4.40	4.05	3.85	3.20	3.20	4.70	2.60	2.20	3.55	3.70
19	3.60	3.90	4.35	3.80	3.65	3.10	3.05	3.85	2.80	2.45	3.45	3.65
20	3.60	6.40	4.30	4.05	3.70	5.00	2.75	3.90	2.45	2.65	3.35	3.35
21	3.60	6.60	4.20	3.95	3.50	5.10	2.70	4.50	2.95	2.55	3.25	3.60
22	3.60	11.25	3.90	3.95	3.45	4.45	3.75	3.85	2.80	2.60	2.75	3.50
23	6.50	11.30	4.30	3.95	3.35	3.90	4.95	3.30	2.75	2.60	3.10	3.[illegible]
24	5.30	8.20	4.90	3.90	3.10	3.40	6.95	3.50	2.65	2.45	3.35	3.[illegible]
25	4.80	6.10	5.50	3.85	3.10	3.40	4.25	3.70	2.50	2.25	3.20	3.50
26	4.20	5.30	5.40	3.95	3.10	3.20	3.25	3.85	2.60	2.50	3.05	3.35
27	4.20	4.40	5.60	4.10	2.95	2.90	3.50	11.10	2.45	2.90	3.00	3.25
28	3.90	4.80	4.95	4.45	3.20	2.75	3.30	10.70	2.60	2.80	3.00	4.10
29	3.80	4.70	4.50	4.15	3.15	2.95	5.85	14.00	2.80	2.65	2.65	5.25
30	3.90	.....	4.50	3.95	3.40	4.20	5.05	5.70	2.70	2.70	2.90	4.55
31	3.90	.....	4.30	.....	3.20	.....	3.90	4.50	.....	2.60	.....	4.20

Rating table for Broad River (of the Carolinas) at Alston, S. C., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.20	1,250	3.20	2,590	4.20	4,750	6.00	9,600
2.30	1,340	3.30	2,770	4.40	5,250	6.50	11,100
2.40	1,440	3.40	2,960	4.60	5,750	7.00	12,600
2.50	1,550	3.50	3,150	4.80	6,300	7.50	14,100
2.60	1,670	3.60	3,350	5.00	6,850	8.00	15,650
2.70	1,800	3.70	3,560	5.20	7,400	8.50	17,275
2.80	1,940	3.80	3,780	5.40	7,950	9.00	18,900
2.90	2,090	3.90	4,010	5.60	8,500	9.50	20,525
3.00	2,250	4.00	4,250	5.80	9,050	10.00	22,150
3.10	2,420						

The above table is based upon 21 discharge measurements made during 1901 to 1904. It is well defined between gage heights 3.0 feet and 10.0 feet.

Estimated monthly discharge of Broad River (of the Carolinas) at Alston, S. C., for 1904.

[Drainage area, 4,609 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	11,100	2,770	3,921	0.851	0.981
February	26,550	3,350	7,237	1.57	1.69
March	21,990	4,010	7,097	1.54	1.78
April	5,888	3,670	4,480	.972	1.08
May	6,025	2,170	3,695	.802	.925
June	7,675	1,870	3,921	.851	.950
July	12,450	1,800	4,169	.905	1.04
August	36,800	2,770	12,200	2.65	3.06
September	7,400	1,495	2,761	.599	.668
October	2,090	1,250	1,614	.350	.404
November	9,900	1,440	3,096	.672	.750
December	17,920	2,250	4,886	1.06	1.22
The year	36,800	1,250	4,923	1.07	14.55

TIGER RIVER AT DELTA, S. C.

This station was established as a bench-mark station. It is located at the Seaboard Air Line Railway bridge, one-third mile east of the depot at Delta, S. C. It is best reached by driving from Whitmire, 4 miles west. Discharge measurements are made from the downstream side of the single-span, steel, through bridge, 202.5 feet long, having trestle approaches at each end. The initial point for soundings is the right end of the bridge, downstream side. Sounding points are marked on the guard rail. The channel is straight for about 1,000 feet above and below the station. The current is swift. Both banks are low, partly wooded, and subject to overflow during high water. The bed of the stream is composed of sand. There is but one channel, divided during high water by the piers of the bridge and trestle supports. The bridge crosses the river at a slight angle. The bench mark is the top of the downstream end of the second floor beam from the right bank. Its elevation is 36.00 feet above gage datum.

Discharge measurements of Tiger River at Delta, S. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
March 22	J. M. Giles	108	409	1.40	1.85	573
May 9	do	109	324	2.09	2.35	678
Septmeber 10	do	106	314	1.18	1.67	369

ENOREE RIVER NEAR WHITMIRE, S. C.

This station was established as a bench-mark station. It is located at the Seaboard Air Line Railway bridge, 1¼ miles east of Whitmire, S. C. There is a highway bridge one-third mile below, and a grist-mill three-fourths mile below has a dam with 2-foot fall. Discharge measurements are made from the downstream side of the single-span deck bridge, 151 feet long. There are 15 bents of trestle approach at the left and 22 bents at the right bank. The initial point for soundings is the right end of the bridge downstream side. Sounding points are marked on the guard rail. The channel is straight for about 300 feet above and one-fourth mile below the station. The current is swift. Both banks are low, clean, and subject to overflow under the trestle approaches. The bed of the stream is composed of gravel and sand. There is but one channel at low and ordinary stages, broken during high water by the piers and trestle work of the bridge. The operation of the mill below will affect the flow of the stream. The bench mark is the top of stringer on the downstream side of the bridge, 50 feet from the initial point for soundings. Its elevation is 56.00 feet above gage datum.

Discharge measurements of Enoree River near Whitmire, S. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
March 23	J. M. Giles	90	237	1.96	1.90	464
May 10	do	100	186	1.65	1.60	307
September 10	do	101	193	1.86	1.20	359

SALUDA RIVER NEAR WATERLOO, S. C.

This station was established by E. W. Myers, August 30, 1896. It is located at the Charleston and Western Carolina Railroad bridge between Coronaca and Waterloo, 3 miles from Waterloo and 9 miles from Greenwood. It is 1 mile below the mouth of Reedy River. The standard chain gage is on the downstream side of the bridge, on the span next the left bank. The length of the chain from the end of the weight to the marker is 45.73 feet. The gage is read once each day by R. N. Cunningham. Discharge measurements are made from the railway bridge and its approaches. The bridge is a steel through bridge of two spans about 125 feet each, with wooden trestles 600 feet long on the left bank and 200 feet on the right bank. The initial point for soundings is the end of the guard rail of the trestle on the left bank. The channel is straight for about 600 feet above and below the station. Both banks are low and wooded and are subject to overflow, but all

water passes beneath the bridge and its approaches. The bed of the stream is sandy and muddy and is slightly shifting. There is but one channel at all stages. Its width at low water is 250 feet, the channel is broken by one pier, and the velocity is moderate.

Bench mark No. 1 is a point on the top surface of the downstream end of the first floor beam to the left of the center pier. Its elevation is 44.64 feet above the gage datum. Bench mark No. 2 is a copper bolt set in a granite bowlder on the right bank of the stream 470 feet from the end of the trestle (measured along the railroad track) and 50 feet upstream from the center of the track. Its elevation is 61.44 feet above gage datum. The rock is near two small persimmon trees.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Saluda River near Waterloo, S. C., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
March 23	E. W. Myers		4,384	2.96	17.40	12,970
April 18	E. C. Murphy		1,213	2.87	9.40	3,481
April 18	B. S. Drane		1,230	3.04	9.60	3,739
April 21	E. W. Myers		1,243	3.01	9.20	3,747
June 25	B. S. Drane		795	1.73	6.76	1,375
June 25	do		829	1.84	7.03	1,527
August 5	J. M. Giles		695	2.22	6.88	1,542
August 5	M. R. Hall		695	2.10	6.88	1,458
September 9	J. M. Giles		628	1.98	6.38	1,245
October 21	do		615	1.91	6.28	1,176
December 9	do		504	1.75	5.90	883
1904.						
January 26	W. E. Hall	160	371	1.29	4.98	479
March 2	J. M. Giles	192	671	2.16	6.85	1,450
March 19	do	191	654	2.02	6.74	1,322
May 5	do	183	540	1.64	5.86	887
July 21	do	163	334	1.73	5.02	578
July 26	do	182	460	1.67	5.57	769
November 16	do	182	593	1.62	6.03	963

Mean daily gage height, in feet, of Saluda River near Waterloo, S. C., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.75	5.60	6.05	6.20	5.65	5.80	6.40	4.70	6.45	5.20	5.05	5.3
2	5.70	5.65	6.15	5.95	5.55	7.75	6.05	7.10	5.85	5.05	5.20	5.7
3	5.50	6.50	6.40	6.45	5.95	5.90	5.15	9.30	6.45	4.20	5.05	6.0
4	5.10	5.45	5.95	6.10	6.00	6.45	4.40	7.20	5.85	5.15	5.70	5.4
5	5.65	5.70	6.10	6.15	5.85	6.05	4.25	6.20	6.45	4.75	5.55	6.9
6	5.95	5.65	5.60	6.65	5.95	4.95	5.45	6.45	6.25	4.75	5.40	5.8
7	5.45	5.65	9.75	6.00	6.05	5.40	5.40	6.65	5.65	4.45	4.45	7.2
8	5.95	6.40	10.60	6.50	5.50	5.75	5.60	19.00	5.75	5.30	5.95	6.2
9	5.80	6.75	8.20	6.85	5.30	6.40	6.65	19.10	5.60	4.65	5.40	5.9
10	5.60	6.65	6.90	7.15	6.10	5.25	5.20	12.75	5.65	4.25	5.35	5.8
11	4.85	6.10	5.90	6.70	5.75	6.15	4.35	9.80	5.65	5.20	5.35	5.9
12	5.65	6.10	6.10	6.00	6.40	5.20	5.15	7.60	5.00	5.15	6.05	5.9
13	5.70	6.55	7.00	5.60	5.20	4.55	5.40	7.60	5.65	4.20	6.05	5.7
14	5.65	6.40	7.30	6.60	6.70	5.35	5.00	7.30	5.50	5.15	5.45	5.5
15	5.60	6.90	6.25	6.40	5.40	5.40	5.45	6.40	5.35	5.00	6.50	5.9
16	5.60	5.60	6.10	6.75	5.25	5.35	4.45	6.45	4.15	5.05	5.50	5.9
17	5.65	6.45	5.70	6.40	6.40	5.45	5.00	6.20	5.05	5.00	5.55	6.1
18	5.20	6.00	5.90	5.80	6.10	6.55	4.30	5.90	5.35	5.15	5.40	5.5
19	5.40	6.50	6.10	6.45	7.10	4.70	5.20	6.15	4.65	5.15	6.00	4.8
20	5.60	6.80	6.60	5.25	6.15	5.70	4.05	6.25	5.40	4.95	5.05	5.6
21	5.70	9.10	5.75	6.35	6.10	5.85	5.00	6.85	5.55	4.70	4.35	5.8
22	7.10	11.10	5.95	6.30	5.40	5.95	5.85	5.60	5.05	4.30	5.30	5.8
23	6.90	11.00	6.00	5.85	4.65	5.80	4.80	5.90	5.55	4.00	5.35	5.6
24	7.10	6.90	7.15	6.30	5.55	5.35	5.70	5.70	6.00	3.95	5.45	5.8
25	6.40	5.80	7.30	5.35	5.65	5.35	5.00	5.70	5.25	3.90	5.25	5.7
26	4.80	5.60	6.40	6.50	5.75	5.95	5.75	10.10	4.30	5.20	5.35	4.8
27	5.60	5.55	7.00	6.05	5.45	4.50	5.55	11.45	5.20	5.00	5.05	5.3
28	5.90	7.05	6.75	6.85	3.95	4.30	7.60	16.90	5.80	5.10	4.35	6.8
29	5.70	6.20	6.00	5.85	5.40	5.30	7.10	7.90	4.55	5.00	5.10	6.3
30	5.85	.....	5.55	6.15	4.80	5.45	6.40	6.80	4.95	4.75	5.35	5.9
31	5.60	.....	5.95	.....	5.95	.....	5.70	6.25	.....	4.25	.....	6.3

NOTE.—The lower gage heights during the latter part of the year were probably caused by the filling of the new dam at Ware Shoals.

Rating table for Saluda River near Waterloo, S. C., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.90	200	4.90	472	5.90	930	7.80	2,100
4.00	219	5.00	510	6.00	985	8.00	2,250
4.10	240	5.10	550	6.20	1,095	8.20	2,400
4.20	262	5.20	592	6.40	1,205	8.40	2,560
4.30	286	5.30	636	6.60	1,320	8.60	2,725
4.40	312	5.40	682	6.80	1,440	8.80	2,900
4.50	340	5.50	730	7.00	1,560	9.00	3,085
4.60	370	5.60	780	7.20	1,690	9.50	3,590
4.70	402	5.70	830	7.40	1,820	10.00	4,150
4.80	436	5.80	880	7.60	1,960		

The foregoing table is based upon discharge measurements made during 1903 and 1904. It is well defined between gage heights 5 feet and 7 feet. Above 7 feet the curve is somewhat uncertain. Above gage height 10 feet the rating curve is a tangent, the difference being 120 per tenth. The table is the same as the 1903 table above 6 feet gage.

Estimated monthly discharge of Saluda River near Waterloo, S. C., for 1904.

[Drainage area, 1,056 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	1,625	436	868	0.822	0.948
February	5,470	706	1,460	1.38	1.49
March	4,870	755	1,398	1.32	1.52
April	1,657	614	1,130	1.07	1.19
May	1,625	210	857	.812	.936
June	2,065	286	798	.756	.844
July	1,960	229	730	.691	.797
August	15,070	402	3,118	2.95	3.40
September	1,233	251	738	.699	.780
October	636	200	444	.420	.484
November	1,260	299	683	.647	.722
December	2,945	436	961	.910	1.05
The year	15,070	200	1,099	1.04	14.16

REEDY RIVER NEAR WATERLOO, S. C.

This station was established as a bench-mark station. It is located at the highway bridge 2 miles from Waterloo, S. C., on the road to Greenwood, S. C. Discharge measurements are made from the downstream side of the single-span, wooden covered, highway bridge 92 feet long, having a trestle approach of 20 feet at the right bank and 400 feet at the left bank. The initial point for soundings is the left end of the downstream truss. The channel is curved for about 500 feet above and straight for about 500 feet below the station. The current is moderate. Both banks are high and wooded. The right bank overflows under the trestle approach, and the left bank over a wide bottom during extreme floods. The bed of the stream is composed of sand. There is but one channel at low and ordinary stages, broken during high water by the piers and trestle bents of the bridge. The bench mark is the top of the downstream bottom chord of truss, 20 feet from the initial point for soundings. Its elevation is 19.00 feet above the gage datum.

Discharge measurements of Reedy River near Waterloo, S. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
July 27	J. M. Giles	75	106	1.62	0.86	172
September 8	do	76	188	1.32	1.15	248

MISCELLANEOUS MEASUREMENTS IN SANTEE RIVER DRAINAGE BASIN.

The following is a list of miscellaneous discharge measurements made in Santee River drainage basin during 1904:

Catawba River near Rock Hill, S. C.—A measurement was made January 30 at Culp's bridge, 8 miles northeast of Rock Hill. The gage height was obtained from gage at Catawba Power Company's dam.

Width, 320 feet; area, 1,797 square feet; mean velocity, 0.92 foot per second; gage height, 99.97 feet; discharge, 1,648 second-feet.

Catawba River near Belmont, N. C.—A measurement was made March 4 at the Southern Railway bridge, 2 miles east of Belmont. The bench mark is the top of the inside bar of the downstream lower chord, at the first crossbeam from the third pier from the left bank. Its elevation was 26.70 feet above the water surface.

Width, 312 feet; area, 1,415 square feet; mean velocity, 1.54 feet per second; discharge, 2,181 second-feet.

Catawba River (South Fork) near Belmont, N. C.—On March 4 a measurement was made at the Southern Railway bridge, 2 miles west of Belmont. The bench mark is the top of crossbeam 67 feet from the left end of the bridge, 25.00 feet above the datum of the gage.

Width, 156 feet; area, 277 square feet; mean velocity, 2.27 feet per second; gage height, 1.70 feet; discharge, 629 second-feet.

On March 5 a measurement was made at the wagon bridge 2 miles southwest of Belmont. The bench mark is the top of the first crossbeam from the left end of the bridge. Its elevation is 24.00 feet above the datum of the gage.

Width, 130 feet; area, 249 square feet; mean velocity, 2.75 feet per second; gage height, 2.35 feet; discharge, 684 second-feet.

Saluda River near Waterloo, S. C.—A measurement was made September 8, at the wagon bridge on the road to Greenwood, S. C. The bench mark is the top of the downstream end of the second crossbeam from the left end of the bridge, 28.65 feet above the datum of the gage.

Width, 145 feet; area, 314 square feet; mean velocity, 1.85 feet per second; discharge, 580 second-feet.

SAVANNAH RIVER DRAINAGE BASIN.

Savannah River is formed by the junction of Tugalo and Seneca rivers, which unite about 100 miles above Augusta, Ga. It flows in a southeasterly direction, forming the boundary between Georgia and South Carolina, and empties into the Atlantic Ocean near Savannah, Ga. It is navigable to Augusta, which is at the fall line.

Seneca River is formed by the junction of Little and Keowee rivers, about 5 miles northeast of Seneca, S. C. Both of these tributaries rise in the Blue Ridge in North Carolina and the northwestern part of South Carolina.

Tugalo River is formed by the junction of Chattooga and Tallulah rivers, which join at the western corner of Oconee County, S. C. It flows in a southeasterly direction, and is a part of the boundary between Georgia and South Carolina. Chattooga River rises in Jackson County, N. C., and flows in a southwesterly direction along the boundary between Georgia and South Carolina. Tallulah River rises in Macon County, N. C., and the northwestern part of Rabun County, Ga., and flows in a southeasterly direction. Parts of its course are cut through the solid rock for hundreds of feet, forming canyons and steep bluffs. Throughout its entire length the fall is very great, and at Tallulah Falls the stream drops more than 500 feet in a short distance.

Broad River joins the Savannah at the southeast corner of Elbert County, Ga. It rises in Habersham and Banks counties, and flows in a southeasterly direction to the southeast corner of Madison County, Ga., where the South Fork joins it. From there it flows east to Savannah River. Its drainage is from a rolling country, and there is a considerable amount of fall at various points. At Anthony Shoals the fall is more than 50 feet in a short distance. Above Augusta, Ga., there is much fall, which can be developed for water power. With exception of the large plant at Augusta, very little of this is being used.

The following pages give the results of the data collected in this drainage during 1904.

TALLULAH RIVER AT TALLULAH FALLS, GA.

This station was originally established August 29, 1900, by M. R. Hall, and records of gage heights were obtained until October 19, 1900, when the observer left Tallulah Falls. The record was resumed January 18, 1901, and maintained until December 31, 1901. The station was reestablished July 10, 1904, on which date bench marks were determined and regular gage readings begun. It is located at the wagon bridge, about one-fourth mile above the falls and about the same distance from the village of Tallulah Falls, Ga. The gage is a vertical rod 10 feet long, graduated to feet and tenths, spiked to a small maple tree on the left bank of the river about 50 feet above the bridge. It is read once each day by J. T. McKay, who is paid by the Georgia Geological Survey. Discharge measurements are made from

the iron wagon bridge, which has a single span of 100 feet and rests on timber piers. The initial point for soundings is the end of the bridge on the upstream side at the left bank. The channel is nearly straight for 300 feet above and for 200 feet below the station. The current is swift. Both banks are high, wooded, rocky bluffs, and are not subject to overflow. The bed of the stream is composed of rock, and is rough and permanent. There is but one channel at all stages. Bench mark No. 1 is the top of a large rock on the right bank, about 30 feet above the bridge. Its elevation is 7.51 feet above the zero of the gage. Bench mark No. 2 is a white paint mark on the downstream rail of the bridge, marked "U. S. 1445." Its elevation is 33.87 feet above the zero of the gage.

Discharge measurements of Tallulah River at Tallulah Falls, Ga., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
March 16	W. E. Hall	51	430	1.14	1.65	490
May 12	do	56	429	1.20	1.86	516
June 11	J. M. Giles	55	385	0.79	1.20	306
June 13	do	56	404	.73	1.05	295
July 15	M. R. Hall	56	354	.51	.70	181
August 22	W. E. Hall	53	360	.63	.92	233
August 23	do	53	357	.61	.80	218
September 29	A. T. Mitchelson	55	330	.44	.50	145
October 28	M. R. Hall	52	327	.38	.40	125
October 28	do	52	321	.40	.41	127
November 23	W. E. Hall	53	354	.48	.77	171
November 23	do	53	349	.48	.75	169

Mean daily gage height, in feet, of Tallulah River at Tallulah Falls, Ga., for 1904.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	0.9	0.9	0.5	0.4	0.7	17	0.7	1.4	0.7	0.4	0.5	0.8
2	.....	1.3	.8	.5	.4	.7	18	.7	1.3	.6	.4	.5	.8
3	.....	1.0	.8	.5	.6	.8	19	.7	1.1	.6	.4	.5	.7
4	.....	.9	1.8	.5	1.0	.8	20	.6	1.5	.7	.4	.5	.7
5	.....	.9	1.5	.5	.9	1.9	21	.6	1.0	.6	.4	.5	.7
6	.....	1.0	1.0	.5	.6	1.7	22	.6	.9	.6	.4	.6	.7
7	.....	2.5	.8	.5	.6	1.1	23	.7	.8	.6	.4	.6	.7
8	.....	2.5	.8	.5	.5	.9	24	.7	1.0	.6	.4	.6	.6
9	.....	1.6	.8	.5	.5	.8	25	1.2	1.4	.6	.4	.6	1.0
10	.....	1.7	.7	.5	.5	.8	26	.8	1.2	.6	.5	.5	.9
11	.....	2.6	.8	.5	.5	.7	27	.7	1.7	.6	.5	.5	.9
12	.....	2.0	.7	.5	.5	.7	28	.7	1.5	.7	.5	.5	2.4
13	.....	2.9	.8	.4	.8	.7	29	.8	1.1	.6	.5	.5	1.5
14	.....	1.7	.8	.4	.7	.7	30	.7	.9	.5	.4	.6	1.3
15	.7	1.5	.7	.4	.6	.7	31	.9	.8	.....	.4	.....	1.1
16	.7	1.4	.7	.4	.5	.7							

Rating table for Tallulah River at Tallulah Falls, Ga., from July 15 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.40	125	1.10	290	1.80	575	2.50	1,000
0.50	145	1.20	320	1.90	630	2.60	1,070
0.60	165	1.30	355	2.00	685	2.70	1,145
0.70	185	1.40	395	2.10	740	2.80	1,220
0.80	210	1.50	435	2.20	800	2.90	1,300
0.90	235	1.60	480	2.30	860	3.00	1,380
1.00	260	1.70	525	2.40	930		

The above table is based upon twelve discharge measurements made during 1904. It is well defined between gage heights 0.4 feet and 2 feet. The table has been extended beyond these limits.

Estimated monthly discharge of Tallulah River at Tallulah Falls, Ga., for 1904.

[Drainage area, 191 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
July 15–31	320	165	195	1.02	0.645
August	1,300	210	447	2.34	2.70
September	575	145	209	1.09	1.22
October	145	125	135	.707	.815
November	260	125	160	.838	.935
December	930	165	266	1.39	.160

TUGALOO RIVER NEAR MADISON, S. C.

This station was originally established July 19, 1898, at Cook's ferry and was discontinued December 31, 1901, when the ferry was moved. It was reestablished July 7, 1903, by M. R. Hall. It is located at Holcomb's ferry, 1 mile west of Madison, S. C., and 900 feet below the Southern Railway bridge. This station is about 1½ miles above the point where the old station was located. The gage consists of a vertical timber in three sections. The first section reads from 1 to 16 feet and is attached to a sycamore tree on the left bank, about 30 feet above the ferry landing. The second section reads from 16 to 22 feet and is attached to a sycamore tree on the left bank, about 18 feet above the ferry landing. The third section reads from 21 to 31 feet and is fastened to a locust tree on the left bank at the forks of the road, about 175 feet from the ferry landing. The gage is read once daily by T. A. Spencer, a farmer. Discharge measurements are made from the ferryboat, or a small boat which is held in place by a cable stretched across the river. The initial point for soundings is the side

away from the river of the windlass used for stretching the cable; it is located on the right bank. Distances are measured along the hand line which is used to pull the boat across the river.

The bed of the river is sandy and the current is moderately swift. The channel is about 160 feet wide and is fairly uniform in width and general appearance for some distance above and below, the current being moderately swift and the channel straight for 1,000 feet or more both above and below the station. The banks are both moderately high, but will overflow for about 200 feet on right bank and 250 feet on the left. Both are open and cultivated except a few trees along the edge of the river. These conditions make it possible to obtain fairly good float measurements at time of floods.

Bench mark No. 1 is a nail in a willow tree on the right bank 20 feet below the ferry landing. It is 7.00 feet above the zero of the gage. Bench mark No. 2 consists of two large nails in the locust tree to which a third section of the gage is attached. They are at an elevation of 22.00 feet above the zero of the gage. Bench mark No. 3 is a copper plug set in solid rock on the north side of the railroad 10½ feet from the north rail and about 400 feet east of the east end of the Southern Railway bridge. Its elevation is 44.27 feet above the zero of the gage. Bench mark No. 4 is the Geological Survey standard bronze tablet marked "666 Atlanta" on the right bank pier of the Southern Railway bridge. Its elevation is 35.37 feet above the zero of the gage, and 665.47 feet above sea level.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Tugaloo River near Madison, S. C., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
June 24	J. M. Giles		724	2.66	4.00	1,927
July 7	M. R. Hall		704	2.38	3.69	1,677
July 9	F. A. Murray		665	2.30	3.40	1,535
July 31	do		579	1.88	2.84	1,091
August 28	do		462	1.72	2.18	798
September 24	do		420	1.70	1.94	715
October 9	J. M. Giles		473	1.96	2.23	927
1904.						
January 13	F. A. Murray	156	388	1.75	1.81	680
March 11	J. M. Giles	166	691	2.43	3.86	1,679
June 10	do	160	425	1.90	2.30	809
July 23	B. S. Drane	157	348	1.78	1.80	622
August 25	W. E. Hall	155	499	2.14	2.96	1,070
September 6	B. S. Drane	157	470	1.91	2.52	896
October 27	M. R. Hall	152	284	1.43	1.41	406

Mean daily gage height, in feet, of Tugaloo River near Madison, S. C., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.70	2.00	2.70	3.35	2.70	3.30	2.40	3.70	2.35	1.60	1.40	1.50
2	1.70	1.90	2.80	3.20	2.70	3.40	2.00	3.95	2.20	1.55	1.40	1.60
3	1.80	1.90	2.80	3.10	2.85	2.80	2.00	2.50	2.40	1.60	1.50	1.60
4	1.70	1.90	2.50	2.95	3.10	2.60	1.90	2.40	3.20	1.55	2.20	1.70
5	1.60	1.90	2.50	2.90	2.90	2.40	1.80	2.40	3.20	1.50	2.20	2.00
6	1.60	1.80	2.30	2.85	2.80	2.35	1.80	2.45	2.65	1.50	2.00	4.90
7	1.90	2.00	13.20	4.10	2.70	2.30	1.80	7.00	2.30	1.50	1.60	2.60
8	1.70	4.80	6.90	3.90	4.95	3.30	1.80	6.90	2.20	1.50	1.50	2.10
9	1.60	3.00	5.00	6.10	6.50	2.50	2.10	4.10	2.20	1.50	1.50	1.90
10	1.60	2.50	4.20	4.50	4.50	2.30	2.30	5.50	2.20	1.55	1.50	1.80
11	1.70	2.60	3.90	4.00	3.60	2.30	2.00	6.60	2.05	1.50	1.50	1.80
12	1.70	2.90	3.60	3.70	3.30	2.30	1.90	5.40	2.10	1.45	1.50	1.80
13	1.80	2.30	3.40	3.50	3.10	2.20	2.10	3.80	2.05	1.45	1.80	1.80
14	1.70	2.10	3.50	3.40	3.05	2.10	1.80	3.30	2.00	1.40	2.00	1.70
15	1.70	2.10	3.60	3.30	3.00	2.10	1.75	2.80	1.90	1.40	1.80	1.70
16	1.60	2.10	3.30	3.20	2.90	2.10	1.70	3.00	1.85	1.40	1.60	1.65
17	1.90	2.10	3.10	3.10	2.80	2.10	1.80	2.50	1.90	1.40	1.50	1.70
18	2.00	2.00	3.05	3.10	2.75	2.10	1.80	2.30	1.80	1.40	1.50	1.75
19	1.80	2.20	2.95	3.00	2.70	2.10	1.70	2.20	1.75	1.35	1.50	1.70
20	1.80	4.40	2.85	2.90	2.60	2.50	1.60	3.80	1.75	1.35	1.50	1.65
21	1.70	3.20	2.80	2.95	2.55	2.50	1.55	2.50	1.75	1.40	1.55	1.60
22	5.10	9.50	5.30	2.90	2.50	2.20	2.20	2.20	1.90	1.35	1.60	1.65
23	6.50	5.40	5.30	2.80	2.50	2.10	1.85	2.05	1.80	1.35	1.80	1.60
24	3.40	4.20	5.80	2.80	2.45	2.00	1.75	2.20	1.70	1.35	1.70	1.60
25	2.80	3.50	4.90	2.80	2.45	1.95	1.90	2.20	1.70	1.40	1.55	1.90
26	2.40	3.20	4.70	2.90	2.40	1.95	2.00	2.85	1.70	1.40	1.50	2.00
27	2.30	3.00	4.30	3.30	2.40	1.90	1.90	4.50	1.70	1.40	1.50	1.95
28	2.20	3.00	4.00	2.90	2.30	1.90	1.70	3.60	1.65	1.40	1.50	7.00
29	2.20	2.80	3.70	2.85	2.25	2.70	2.00	2.80	1.70	1.45	1.50	3.50
30	2.10	.....	3.50	2.80	2.40	3.60	1.90	2.50	1.60	1.40	1.50	2.70
31	2.00	.....	3.40	.....	5.20	.....	3.95	2.30	.....	1.40	.....	2.30

Rating table for Tugaloo River near Madison, S. C., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.35	435	2.40	868	3.50	1,458	5.20	2,665
1.40	452	2.50	915	3.60	1,519	5.40	2,830
1.50	490	2.60	963	3.70	1,582	5.60	3,000
1.60	528	2.70	1,012	3.80	1,646	5.80	3,180
1.70	567	2.80	1,062	3.90	1,710	6.00	3,365
1.80	607	2.90	1,114	4.00	1,775	6.20	3,555
1.90	648	3.00	1,168	4.20	1,905	6.40	3,745
2.00	690	3.10	1,224	4.40	2,045	6.60	3,940
2.10	733	3.20	1,281	4.60	2,195	6.80	4,140
2.20	777	3.30	1,339	4.80	2,345	7.00	4,340
2.30	822	3.40	1,398	5.00	2,505		

The foregoing table is based upon 7 discharge measurements made during 1904 It is fairly well defined between gage heights 1.50 feet and 4 feet.

Estimated monthly discharge of Tugaloo River near Madison, S. C., for 1904.

[Drainage area, 593 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	3,840	528	829	1.40	1.61
February	7,325	607	1,304	2.20	2.37
March	14,450	822	2,100	3.54	4.08
April	3,460	1,062	1,369	2.31	2.58
May	3,840	800	1,259	2.12	2.44
June	1,519	648	880	1.48	1.65
July	1,742	509	682	1.15	1.33
August	4,340	712	1,543	2.60	3.00
September	1,281	528	717	1.21	1.35
October	528	435	469	.791	.912
November	777	452	539	.909	1.01
December	4,340	490	830	1.40	1.61
The year	14,450	435	1,043	1.76	23.94

SAVANNAH RIVER AT AUGUSTA, GA.

Observations of river heights have been maintained since 1875 by the city of Augusta at the city highway bridge. The results have been printed in a volume entitled "Stages of Water at River Stations," prepared by the United States Weather Bureau. Those for 1875 to 1889 are given in part 3, those for 1890 to 1892 in part 4, and those for 1893 to 1895 in part 5 of this publication. The gage consists of a vertical timber fastened to the pier and graduated to feet and inches. Readings are made four times a day by J. M. Youngblood, keeper of the city bridge, usually at 6 a. m., 12 m., 6 p. m., and 9 p. m. The 6 a. m. readings are those used by the Weather Bureau, but in the publications of the United States Geological Survey since 1900 the average of all four of the daily readings is used and is reduced to feet and tenths of feet.

Discharge measurements are made from the North Augusta Bridge at Thirteenth street in the city of Augusta, while the city gage is located at the city bridge at Fifth street, which is about a mile below.

The North Augusta Bridge consists of three iron spans, 208 feet each, with 319 feet of wooden approach on the right bank and 259

feet on the left. The channel is straight for a long distance above and below and is about 560 feet wide at low water. The banks are high, but will overflow at times under a part of the length of the approaches and, at very high stages, for a long distance on either side of the river beyond the ends of the bridge. The bed of the river is sandy and undergoes considerable change. The current is swift. Measurements are made from the downstream side of the bridge, and the initial point is the end of the iron bridge at the right bank on the downstream side.

The gage at the city bridge, 1 mile below the measuring station, is a heavy vertical timber, graduated to feet and inches, and is bolted to the first bridge pier which is in the water. It is on the side of the pier near the upstream corner, facing the right bank. The zero of the gage is the datum of all the city levels, and any city bench mark can therefore be used. A point is established on the North Augusta bridge from which to measure down with a steel tape. This is the top of the plate through which the top pipe of the bridge fencing passes, which is riveted to the right side of the intermediate post at the downstream end of the third floor beam from the right-bank end of the bridge, and at ordinary stages it is 55.00 feet above water, less the reading of the gage.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Savannah River at Augusta, Ga., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
June 10	M. R. Hall	.....	7,303	2.43	15.10	17,740
September 29	do	.....	3,075	1.24	7.13	3,831
December 3	W. E. Hall	.....	3,069	1.27	7.20	3,898
1904.						
February 5	M. R. Hall	526	3,293	1.43	7.50	4,714
February 15	W. E. Hall	534	3,978	1.69	8.70	6,714
April 7	M. R. Hall	518	3,484	1.62	7.96	5,647
July 14	W. E. Hall	519	2,904	1.32	6.45	3,826
August 10	M. R. Hall	601	13,200	4.22	24.57	55,680
October 9	do	522	2,387	1.29	5.77	3,068
October 18	do	522	1,998	1.03	5.07	2,057

Mean daily gage height,[a] in feet, of Savannah River at Augusta, Ga., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	7.3	8.0	8.8	8.6	7.4	9.2	6.8	7.7	7.3	5.3	5.1	5.7
2	7.2	7.9	8.6	8.6	7.5	11.2	7.5	7.1	7.0	4.8	4.8	6.0
3	7.1	7.9	8.6	8.3	7.3	9.1	6.8	8.9	7.0	5.3	5.4	6.3
4	7.2	7.7	8.7	8.2	7.3	7.9	5.8	8.6	6.2	5.2	5.4	6.9
5	7.3	7.6	8.4	8.1	7.6	7.0	6.4	10.4	9.3	4.9	5.6	7.3
6	7.2	7.7	8.1	8.0	7.5	6.9	6.0	8.6	11.1	5.0	6.3	8.4
7	7.1	7.4	10.4	7.9	7.3	7.0	5.5	8.4	10.4	5.3	6.7	11.5
8	6.8	9.0	16.3	8.2	7.0	7.5	5.6	16.3	8.1	4.7	6.5	9.8
9	7.0	11.9	16.2	9.1	8.8	8.0	5.1	24.5	7.3	3.8	6.4	8.2
10	7.0	11.2	12.6	10.1	8.9	7.1	6.2	24.5	7.0	5.5	6.0	7.7
11	7.3	14.4	10.5	9.3	8.9	6.0	7.0	19.1	6.5	5.2	5.6	7.2
12	7.4	12.7	9.7	8.7	8.0	6.0	6.9	14.3	6.7	4.1	5.5	7.2
13	7.6	10.7	9.3	8.4	7.6	6.7	6.7	11.8	6.4	5.2	5.4	7.0
14	7.4	9.2	9.1	8.2	7.5	6.6	6.3	9.6	6.3	4.6	6.6	7.1
15	7.5	8.7	9.1	8.0	7.0	6.5	5.7	9.3	6.1	4.5	6.8	7.0
16	7.5	8.6	9.4	8.0	7.1	6.4	5.4	10.3	6.1	3.8	7.0	7.0
17	7.2	8.4	9.0	7.8	7.2	6.2	4.8	10.7	5.8	5.5	6.7	6.9
18	7.5	8.2	8.4	8.0	7.0	6.0	5.6	9.1	5.5	4.3	6.3	7.4
19	7.7	8.1	8.4	8.0	7.0	5.2	5.4	8.3	5.7	4.5	5.9	7.6
20	7.6	8.9	8.2	7.9	6.8	6.5	5.5	7.6	5.5	4.3	5.4	7.1
21	7.4	11.6	8.3	7.8	6.8	6.6	5.3	10.1	5.5	5.1	6.3	7.1
22	7.6	14.6	8.5	7.7	6.5	7.1	5.2	9.0	5.6	4.2	5.8	6.8
23	13.1	18.5	9.6	7.7	6.7	7.2	5.0	7.4	5.7	3.8	5.4	6.8
24	13.4	15.7	11.1	7.5	6.6	6.7	10.1	7.1	5.6	5.5	5.9	6.3
25	11.5	12.5	13.4	7.5	6.4	6.1	7.7	6.9	5.5	4.8	6.2	6.1
26	9.4	10.6	11.9	7.6	6.4	5.4	8.7	6.8	5.7	4.8	5.9	6.4
27	8.5	9.5	10.5	7.6	6.4	6.2	7.8	9.2	5.4	4.2	5.6	6.8
28	8.2	9.1	10.4	7.9	6.4	5.7	7.6	12.5	5.5	5.4	6.2	7.8
29	8.2	9.0	9.6	7.8	5.6	5.7	9.5	12.4	5.6	5.3	5.7	9.7
30	8.0	.....	9.1	7.6	5.6	6.6	8.5	9.9	5.3	3.8	5.4	9.9
31	7.9	.....	8.8	.....	6.8	.....	6.8	8.0	.....	5.6	.....	8.3

[a] All gage heights mean of four readings per day: 6 a. m., 12 m., 6 p. m., 9 p. m

Rating table for Savannah River at Augusta, Ga., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.80	1,450	5.80	2,870	13.50	15,080	21.50	38,900
3.90	1,500	6.00	3,050	14.00	16,200	22.00	41,000
4.00	1,550	6.50	3,550	14.50	17,350	22.50	43,300
4.10	1,610	7.00	4,100	15.00	18,550	23.00	45,800
4.20	1,670	7.50	4,680	15.50	19,780	23.50	48,700
4.30	1,730	8.00	5,300	16.00	21,050	24.00	52,000
4.40	1,790	8.50	5,980	16.50	22,350	24.50	55,750
4.50	1,850	9.00	6,700	17.00	23,700	25.00	60,000
4.60	1,920	9.50	7,480	17.50	25,120	25.50	64,500
4.70	1,990	10.00	8,300	18.00	26,600	26.00	69,000
4.80	2,060	10.50	9,150	18.50	28,170	26.50	73,500
4.90	2,130	11.00	10,050	19.00	29,800	27.00	78,000
5.00	2,200	11.50	10,980	19.50	31,470	27.50	82,500
5.20	2,360	12.00	11,950	20.00	33,200	28.00	87,000
5.40	2,520	12.50	12,950	20.50	35,020		
5.60	2,690	13.00	14,000	21.00	36,900		

The above table is based upon discharge measurements made during 1899–1904 and is fairly well defined.

Estimated monthly discharge of Savannah River at Augusta, Ga., for 1904.

[Drainage area, 7,294 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	14,860	3,880	5,583	0.765	0.882
February	28,170	4,560	9,206	1.26	1.36
March	21,830	5,430	8,579	1.18	1.36
April	8,470	4,680	5,512	.756	.844
May	6,550	2,690	4,292	.588	.678
June	10,410	2,360	4,088	.560	.625
July	8,470	2,060	3,769	.517	.596
August	55,750	3,880	11,710	1.61	1.86
September	10,230	2,440	3,796	.520	.580
October	2,690	[a] 1,450	2,079	.285	.329
November	4,100	2,060	3,015	.413	.461
December	10,980	2,780	4,772	.654	.754
The year	55,750	1,450	5,533	.759	10.33

[a] The low days in October occurred on Sundays, when the mills were not running, and water was being held back by the dam.

CHAUGA RIVER NEAR FORT MADISON, S. C.

A station was established on Chauga River at Bryan wagon bridge, 2 miles east of Fort Madison and 1 mile above the mouth of the river, by M. R. Hall, and measurements were made during 1900 and 1901 in connection with the old station on Tugaloo River at Cooks Ferry. When the Tugaloo River station was reestablished in 1903 the Chauga River station was also reestablished as a bench-mark station. No gage has been established, but all discharge measurements are referred to a bench mark. Discharge measurements are made from the upstream side of the single-span wooden bridge. The bridge is supported by log cribs which are filled with rock and anchored to bed rock. The floor of the bridge is about 10 feet above low water. The initial point for soundings is the top of anchor bolt in upstream corner of the right bank abutment. The channel is straight for about 500 feet above the station; below, it is curved for about 50 feet, and then straight. The current is swift. The right bank is high, clean, and liable to overflow during freshets. The left bank is high, rocky, wooded, and is not subject to overflow. Floods can not be measured, as high water goes over the bridge. Bench mark No. 1 is a nail in a sycamore sapling on the left bank about 100 feet above the bridge. Bench mark No. 2 is the top of the downstream guard rail 7 feet from right bank. Its elevation is 10.00 feet. Bench mark No. 3 is a large nail driven horizontally in the center of the downstream end of the lowest cross log of the right bank crib abutment. Elevation, 4.50 feet above datum.

Discharge measurements of Chauga River near Fort Madison, S. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
June 10	J. M. Giles	39	61	1.49	0.91	91
September 5	B. S. Drane	40	87	1.64	1.20	143
October 27	M. R. Hall	37	48	1.33	.44	64

SENECA RIVER NEAR CLEMSON COLLEGE, S. C.

This station was established by M. R. Hall as a regular station on December 8, 1903, at which time a boxed chain gage was installed and the bench marks were established. A vertical gage had been put in July 19, 1903, by F. A. Murray, and records obtained from it for a portion of the time. The station is located at the iron wagon bridge about 3 miles south of Clemson College, S. C., and about 300 feet up the river from the crossing of the Blue Ridge Railroad, which is a branch of the Southern Railway. The bridge is a single span of iron, about 157 feet long, with 40 feet of trestle approach on the right bank and 70 feet on the left bank. At ordinary stages the channel is about

150 feet wide. The right bank is high and will not overflow, but the left bank will overflow for a considerable width at a gage height of about 23 feet. The bed of the river is sandy. The current is moderate. At low stages there is a daily fluctuation of about 1 foot in the gage heights, caused by the operation of water powers above. On this account the gage is read twice each day, and a mean of the two readings is used. The observer is M. L. Sanders.

Discharge measurements are made from the downstream side of the bridge, and the initial point is the center of the tubular iron pier at the right bank downstream. The boxed chain gage is located on the lower chord on the downstream side. The 24-inch box extends from 20 to 22 feet from the initial point. The chain is 31.82 feet long from the bottom of the weight to the marker. The vertical gage is of 2 by 4 inch timbers in 5-foot sections, fastened to a scantling which is clamped to the iron braces between the cylinders of the right bank pier. Both gages are in good condition, except that mud accumulates at the lower end of the vertical gage.

Bench mark No. 1 is the top of the upstream cylinder of the right bank pier at a point marked "B. M." by chisel cuts. Its elevation is 28.95 feet above gage datum. Bench mark No. 2 is a copper plug set in rock on the right bank under the railroad bridge and about 20 feet to the right of the center pier. Its elevation is 10.27 feet above gage datum. This rock is low and has been uncovered by erosion of the bank. Bench mark No. 3 is a bench cut on the root of a hickory tree at the fork of the roads about 100 feet from the right bank end of the bridge. Its elevation is 30.52 feet above gage datum.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Seneca River near Clemson College, S. C., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
July 10	F. A. Murray	148	748	1.85	4.54	1,388
July 28	do	148	525	1.82	3.53	959
July 29	do	148	538	2.00	3.56	1,077
August 27	do	147	434	2.00	3.14	869
September 23	do	134	316	1.95	2.51	616
October 9	J. M. Giles	149	473	2.22	3.43	1,050
December 8	W. E. Hall	131	326	1.65	2.21	539
1904.						
January 14	F. A. Murray	128	336	1.78	2.23	601
January 14	do	140	426	1.88	2.87	802
January 28	W. E. Hall	148	529	1.94	3.41	1,027

Discharge measurements of Seneca River near Clemson College, S. C., etc.—Continued.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1904—Cont'd.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
March 10	J. M. Giles	148	722	2.33	5.28	1,680
March 11	do	148	653	2.29	4.76	1,497
May 11	W. E. Hall	148	488	2.00	3.43	978
June 9	J. M. Giles	147	494	1.86	3.55	920
June 9	do	147	524	1.94	3.73	1,015
July 16	B. S. Drane	142	208	1.37	1.41	286
August 25	W. E. Hall	128	331	1.54	2.38	509
September 6	B. S. Drane	148	487	1.90	3.40	924
October 5	do	145	300	1.73	2.15	520
December 6	do	150	874	2.60	6.35	2,274
December 6	do	150	778	2.44	5.52	1,901

Mean daily gage height, in feet, of Seneca River near Clemson College, S. C., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.55	2.85	3.20	3.80	3.10	6.40	2.95	4.45	2.70	2.40	1.90	2.25
2	2.65	2.75	3.55	3.80	3.15	4.00	2.50	3.95	3.15	2.25	1.95	2.15
3	2.50	2.85	3.40	3.10	3.45	3.30	2.40	3.25	2.80	2.25	1.90	2.25
4	2.75	2.85	3.30	3.50	3.35	3.20	2.10	2.65	2.55	2.00	3.05	2.05
5	2.30	2.80	3.45	3.40	3.60	2.85	1.75	3.15	3.20	1.95	2.70	2.90
6	2.30	2.60	3.05	3.50	3.25	3.20	2.30	4.45	3.10	1.95	2.55	6.10
7	2.60	2.70	11.70	4.75	3.05	4.20	2.30	7.00	2.70	1.85	2.55	3.75
8	2.70	4.45	8.00	5.25	3.65	4.80	2.00	9.00	2.70	1.50	2.00	3.40
9	2.55	3.90	6.00	5.25	6.20	3.60	2.50	5.10	2.80	1.80	1.95	3.55
10	2.45	3.70	5.10	4.15	4.35	3.10	2.50	4.00	2.70	1.80	2.15	2.70
11	2.75	3.65	4.80	4.25	4.15	3.40	2.45	5.50	2.80	1.95	2.05	2.80
12	2.50	3.25	4.55	3.95	3.45	2.75	2.40	6.00	2.65	2.40	2.45	2.65
13	2.50	3.25	4.15	3.95	3.40	2.70	2.40	4.60	2.75	1.80	2.60	2.45
14	2.50	3.10	4.25	3.70	3.35	2.70	2.40	3.70	2.75	2.30	2.70	2.40
15	2.50	2.75	4.05	3.75	3.20	2.50	2.10	3.15	2.45	2.25	2.90	2.40
16	2.50	2.95	3.90	4.10	3.20	2.70	2.05	5.35	2.45	1.85	2.60	2.30
17	2.60	2.70	3.75	3.75	3.00	2.60	2.45	3.70	2.50	1.75	2.25	2.50
18	2.75	2.75	3.75	3.50	3.20	2.50	2.40	3.60	2.35	1.75	2.20	2.50
19	2.50	3.25	3.70	3.45	3.00	2.30	2.55	2.85	2.45	1.25	2.60	2.45
20	2.50	5.70	3.30	3.45	3.00	3.55	1.85	4.40	2.05	1.30	2.15	2.30
21	2.45	4.45	3.60	3.45	3.10	3.00	2.00	3.10	2.45	1.40	2.25	2.50
22	3.05	10.15	4.80	3.40	2.50	2.50	2.45	2.50	2.90	1.70	2.25	2.50
23	6.90	6.45	5.70	3.50	2.95	2.50	2.55	2.90	3.00	1.40	2.80	2.15
24	4.35	5.15	6.50	3.50	2.75	2.45	2.00	2.85	2.90	1.60	2.60	1.95
25	3.85	4.35	5.30	3.20	2.50	2.20	2.60	3.20	2.35	1.70	2.65	2.15
26	3.25	3.75	4.20	3.30	2.50	2.00	2.70	3.10	2.40	1.80	2.60	2.45
27	3.10	4.05	4.70	3.60	2.50	2.05	2.10	4.30	2.25	1.75	2.05	2.95
28	3.00	4.00	4.40	3.10	2.40	2.45	2.30	4.75	3.45	1.80	2.05	3.25
29	3.10	3.55	4.30	3.20	2.55	3.10	2.45	3.10	2.95	1.70	2.05	4.00
30	3.05	.....	4.10	3.50	3.10	4.10	2.40	3.15	2.90	1.45	2.05	3.00
31	2.85	.....	3.90	.....	7.00	.....	2.45	3.00	.....	1.75	.....	2.95

Rating table for Seneca River near Clemson College, S. C., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.40	285	2.30	544	3.20	859	4.20	1,265
1.50	310	2.40	577	3.30	897	4.40	1,351
1.60	336	2.50	610	3.40	936	4.60	1,440
1.70	363	2.60	644	3.50	975	4.80	1,530
1.80	391	2.70	678	3.60	1,015	5.00	1,620
1.90	420	2.80	713	3.70	1,055	5.50	1,870
2.00	450	2.90	749	3.80	1,096	6.00	2,120
2.10	481	3.00	785	3.90	1,138	6.50	2,395
2.20	512	3.10	822	4.00	1,180	7.00	2,670

The above table is based upon discharge measurements made during 1903 and 1904. It is fairly well defined to gage height 6.4 feet. Discharges above 7-foot gage approximate estimates.

Estimated monthly discharge of Seneca River near Clemson College, S. C., for 1904.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
January	2,615	544	769
February	4,700	644	1,162
March	5,800	804	1,506
April	1,745	822	1,078
May	2,670	577	943
June	2,340	450	841
July	767	377	557
August	3,920	610	1,253
September	956	466	683
October	577	250	377
November	804	420	564
December	2,148	435	741
The year	5,800	250	873

ROCKY RIVER NEAR CALHOUN FALLS, S. C.

This station was established as a bench-mark station. It is located at a highway bridge just below Swearingen's mill, about 3½ miles northwest of Calhoun Falls, S. C. Discharge measurements are made from the downstream side of the bridge, which is 110 feet long and supported by two timber piers. The initial point for soundings is the right end of the downstream guard rail. The channel is curved for about 200 feet above and straight for 300 feet below the station. The current is swift. Both banks are subject to overflow during high

water. The bed of the stream is composed of sand and gravel and is very changeable. The washing out and filling in of the channel prevents rating. The bench mark is the top of the downstream end of trestle cap on the left side of pier next the right bank. Its elevation is 6.00 feet above gage datum.

Discharge measurements of Rocky River near Calhoun Falls, S. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
March 17	J. M. Giles	60	143	1.76	1.60	251
September 7	do	91	114	1.74	2.50	198

BROAD RIVER (OF GEORGIA) NEAR CARLTON, GA.

This station was established May 27, 1897, by M. R. Hall. The gage is now maintained and the observer paid by the United States Weather Bureau. The station is located at the Seaboard Air Line Railroad bridge 3 miles east of Carlton, Ga., and 2 miles above the mouth of the South Fork. The boxed chain gage is bolted to the guard rail, with its bottom resting on the upstream end of the cross-ties. The center of the pulley is 39.5 feet from the initial point for soundings. The length of the chain from the end of the weight to the marker is 54.00 feet. The observer is S. P. Powers, jr., who reads the gage once each day. Discharge measurements are made from the upstream side of the railway bridge to which the gage is attached. This is an iron deck bridge in two spans of 125 feet each, with trestle approaches 340 feet long on the left bank and 50 feet long on the right bank. The base of the rail of the track is about 51 feet above low water. The initial point for soundings is the end of the iron bridge on the right bank upstream side. The channel above and below the station is straight for 500 feet. The right bank is high and wooded and is not liable to overflow. The left bank is low for about 400 feet and is then high and rocky. It overflows at a gage height of about 16 feet. The bed of the stream is sand and gravel, and is somewhat changeable.

Bench mark No. 1 is the top of the upstream iron girder under the cross-ties at a point about 40 feet from the initial point for soundings. Its elevation is 51.00 feet above gage datum. Bench mark No. 2 is the top of the capstone of the right bank pier at a point under the upstream side of the end of the bridge. Its elevation is 30.78 feet above the gage datum. Bench mark No. 3 is a copper plug set in solid rock in the railroad cut 1,135 feet from the west end of the iron bridge, 11 feet north of the center of the track, and at about the same elevation as the bottom of the cross-ties. Its elevation above gage datum is 57.67 feet. Gage datum is 384 feet above sea level.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Broad River (of Georgia) near Carlton, Ga., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
March 21	J. M. Giles	207	859	3.02	4.55	2,592
May 8	do	185	582	2.13	3.10	1,242
June 11	do	200	734	2.40	3.65	1,766
August 14	do	181	456	2.09	2.70	953
September 16	do	198	877	2.77	4.52	2,435
October 29	do	162	359	1.69	2.16	606
December 8	do	172	395	1.59	2.20	628
1904.						
March 17	J. M. Giles	181	469	1.72	2.62	809
May 5	do	155	394	1.47	2.20	581
July 21	do	129	250	1.20	1.48	299
September 6	do	175	512	1.44	2.37	737
November 15	do	147	399	1.15	1.88	460

Mean daily gage height, in feet, of Broad River (of Georgia) near Carlton, Ga., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.2	2.6	2.6	2.5	2.2	2.4	2.1	1.6	1.9	1.5	1.6	1.9
2	2.2	2.5	2.6	2.5	2.2	2.5	2.0	2.6	1.9	1.5	1.6	2.0
3	2.3	2.4	2.8	2.5	2.1	2.1	1.9	2.4	1.8	1.5	1.7	2.5
4	2.3	2.4	2.8	2.4	2.1	2.0	1.8	2.0	2.4	1.5	1.9	2.1
5	2.2	2.3	2.6	2.4	2.1	1.9	1.7	1.9	3.2	1.5	2.1	2.4
6	2.2	2.3	2.6	2.4	2.1	1.9	1.7	2.8	2.8	1.5	2.0	4.2
7	2.2	2.5	3.7	2.6	2.2	2.1	1.6	2.5	2.7	1.5	1.8	3.2
8	2.2	3.4	5.7	2.6	2.2	2.2	1.6	6.5	2.1	1.5	1.7	2.6
9	2.2	3.1	4.8	2.7	3.5	1.9	4.2	10.4	2.0	1.5	1.7	2.4
10	2.2	3.0	3.4	2.5	3.0	1.9	2.7	6.3	1.9	1.5	1.6	2.2
11	2.3	3.3	3.0	2.5	2.4	1.8	2.0	4.2	1.8	1.5	1.6	2.3
12	2.3	3.0	2.8	2.4	2.2	1.8	2.0	3.3	1.8	1.5	1.6	2.1
13	2.4	2.7	2.7	2.4	2.2	1.8	2.0	3.0	1.8	1.5	2.0	2.0
14	2.4	2.6	2.9	2.3	2.1	1.8	1.8	2.7	1.7	1.5	2.2	2.0
15	2.3	2.6	3.0	2.3	2.1	1.7	1.7	2.5	1.7	1.5	2.0	2.0
16	2.2	2.5	2.8	2.3	2.1	1.7	1.6	2.6	1.7	1.5	1.9	2.0
17	2.3	2.5	2.7	2.4	2.0	1.7	2.1	2.4	1.6	1.5	1.9	2.0
18	2.5	2.4	2.6	2.4	2.0	1.6	1.8	2.2	1.6	1.5	1.8	2.0
19	2.4	2.4	2.6	2.3	2.0	1.8	1.6	2.1	1.6	1.5	1.8	2.0
20	2.2	3.6	2.5	2.3	2.0	1.7	1.5	4.2	1.6	1.5	1.7	1.9
21	2.2	3.3	2.5	2.4	1.9	2.5	1.5	2.9	1.6	1.5	1.7	1.9
22	2.2	4.8	4.0	2.3	1.9	2.1	1.6	2.1	2.1	1.5	1.7	1.9
23	3.8	4.6	3.4	2.3	1.9	2.0	1.9	2.0	1.6	1.5	1.9	1.9
24	3.2	3.7	4.3	2.2	1.9	1.7	1.8	1.9	1.6	1.5	2.3	1.9
25	2.7	3.4	3.5	2.2	1.8	1.7	1.6	1.9	1.6	1.5	2.0	2.0
26	2.5	2.9	3.3	2.3	1.8	1.6	2.6	1.9	1.6	1.6	1.9	2.1
27	2.4	2.8	3.0	2.4	1.8	1.6	1.9	3.1	1.6	1.7	1.8	2.1
28	2.4	2.7	2.9	2.3	1.8	1.6	1.7	3.3	1.6	1.7	1.8	3.3
29	2.5	2.6	2.7	2.2	1.8	1.9	3.0	2.9	1.6	1.6	1.7	3.0
30	2.6	.....	2.6	2.2	3.0	2.3	1.8	2.2	1.5	1.6	1.7	2.5
31	2.5	.....	2.6	.....	3.4	.....	1.6	2.0	.....	1.6	.....	2.3

Rating table for Broad River (of Georgia) near Carlton, Ga., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.50	305	2.70	920	3.80	1,770	5.80	3,840
1.60	340	2.80	990	3.90	1,860	6.00	4,100
1.70	380	2.90	1,060	4.00	1,950	6.50	4,750
1.80	420	3.00	1,130	4.20	2,130	7.00	5,400
1.90	460	3.10	1,200	4.40	2,320	7.50	6,100
2.00	510	3.20	1,280	4.60	2,520	8.00	6,800
2.10	560	3.30	1,360	4.80	2,720	8.50	7,500
2.20	610	3.40	1,440	5.00	2,920	9.00	8,200
2.30	670	3.50	1,520	5.20	3,140	9.50	8,950
2.40	730	3.60	1,600	5.40	3,360	10.00	9,700
2.50	790	3.70	1,680	5.60	3,600	10.50	10,450
2.60	850						

The above table is based upon discharge measurements made during 1900–1904. It is well defined between gage heights 1.5 feet and 5.3 feet. Above this latter point the curve is based on one measurement at 9.1 feet.

Estimated monthly discharge of Broad River (of Georgia) near Carlton, Ga., for 1904.

[Drainage area, 762 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	1,770	610	741	0.972	1.12
February	2,720	670	1,113	1.46	1.58
March	3,720	790	1,247	1.64	1.89
April	920	610	720	.945	1.05
May	1,520	420	629	.825	.951
June	790	340	478	.627	.700
July	2,130	305	522	.685	.790
August	10,300	340	1,409	1.85	2.13
September	1,280	305	471	.618	.690
October	380	305	314	.412	.475
November	670	340	434	.570	.636
December	2,130	460	688	.903	1.04
The year	10,300	305	730	.959	13.05

BROAD RIVER (SOUTH FORK) NEAR CARLTON, GA.

This station was established as a bench-mark station. It is located at Bull Rat Rock, about 1 mile south of Carlton, Ga. Discharge measurements are made at a shoal about 100 yards above the rock by means of a boat. The initial point for soundings is a small sweet gum tree on the left bank. The channel is curved for 200 feet above and 500 feet below the station. The current is sluggish. The right bank is cultivated, and the left is wooded. Both banks are subject to overflow at rare intervals. The bed of the stream is composed of rock and is very rough. The bench mark is composed of three copper nails driven into the gum tree, which forms the initial point for sounding. Its elevation is 5.00 feet above datum.

Discharge measurements of Broad River (South Fork) near Carlton, Ga., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
July 20	J. M. Giles	100	179	0.36	1.00	64
September 7	do	105	158	.73	1.20	115

MISCELLANEOUS MEASUREMENTS IN SAVANNAH RIVER DRAINAGE BASIN.

The following is a list of miscellaneous discharge measurements made in Savannah River drainage basin during 1904:

Keowee River near Calhoun, S. C.—Keowee River is tributary to Seneca River from the north near Seneca, S. C. A measurement was made January 16 from the Lawrence Bridge, 5 miles northwest of Calhoun. The bench mark is the top of the upstream end of the first iron cross bream from the right bank, 27.00 feet above the datum of the gage.

Width, 144 feet; area, 620 square feet; mean velocity, 1.11 feet per second; gage height, 2.91 feet; discharge, 691 second-feet.

Tiger Creek at Wiley, Ga.—This stream is tributary to Tallulah River from the north, entering near Tallulah Falls, Ga. A measurement was made June 13 from the railroad trestle, one-fourth mile northwest of Wiley.

Width, 14 feet; area, 11 square feet; mean velocity, 1.12 feet per second; discharge, 12.3 second-feet.

Broad River (South Fork) near Comer, Ga.—A measurement was made March 16 at the Seaboard Air Line Railroad bridge, 1½ miles west of Comer. The bench mark is the top of the girder at sounding point 30. Its elevation is 49.00 feet above the datum of the gage.

Width, 74 feet; area, 68 square feet; mean velocity, 1.56 feet per second; gage height, 1.18 feet; discharge, 106 second-feet.

Broad River (South Fork) near Carlton, Ga.—A measurement was made May 4 at the foot of the shoals below Watson's mill.

Width, 50 feet; area, 81 square feet; mean velocity, 1.28 feet per second; discharge, 104 second-feet.

The gage at Carlton read 2.20 feet.

Clouds Creek near Carlton, Ga.—This stream is tributary to Broad River. A measurement was made May 4 below the ford on the public road one-half mile east of Watson's mill, near Carlton.

Width, 36 feet; area, 36 square feet; mean velocity, 1 foot per second; discharge, 36 second-feet.

The gage at Carlton read 2.20 feet.

OGEECHEE RIVER DRAINAGE BASIN.

Ogeechee River is formed by the junction of Williamsons Swamp Creek and Rocky Comfort Creek in Jefferson County, Ga., and drains a small basin in southeastern Georgia lying between the Savannah and Altamaha basins. Ogeechee River flows in a southeasterly direction and empties into the Atlantic Ocean. Its main tributary is Cannoochee River, which rises in Emanuel County, Ga., flows southeast, and joins the Ogeechee about 20 miles from the Atlantic Ocean. The streams in this basin flow through a country that is mostly low. The current is generally good, but the fall available for power is probably small. The bank on one side or the other of the stream is generally low and swampy.

The following pages give the results of the data collected in this drainage during 1904:

WILLIAMSONS SWAMP CREEK AT DAVISBORO, GA.

This station was established June 19, 1903, by F. A. Murray. It is located at the Davisboro Bridge, about 200 yards south of the Central of Georgia Railroad station, which is in the middle of the town. The gage is a vertical 1 by 3 inch wooden rod 10 feet long, graduated to feet and tenths with notches and numbered with brass figures. The rod is nailed to the left side of the upstream post of the bent which supports the bridge at a point 302 feet from the initial point for soundings. The gage is read once each day by A. Baker, a hotel proprietor, who is paid by the Georgia Geological Survey. Discharge measurements are made from the upstream side of the wooden highway bridge, which is supported by wooden bents about 18 feet apart. The initial point for soundings is the outer edge of the post which supports the end of the hand rail on the left bank upstream side of the bridge. The channel is straight for about 200 feet above and below the station. The right bank is low and overflows at a gage reading of

4 to 4½ feet. The left bank will overflow at a gage height of 3 feet. The bed of the stream is sandy and is slightly shifting. There is but one channel at all stages. The current is somewhat obstructed by the bents which support the bridge at low water and by trees and brush on the banks at high water.

Bench mark No. 1 is the top of the bridge floor at the bent 302 feet from the initial point for soundings on the upstream side of the bridge. The point is marked with a cross and the letters "B. M." cut into the top of the bridge-floor plank. Its elevation is 11.00 feet above the zero of the gage, which is attached to the same bent. Bench mark No. 2 is the center of a large wire nail driven horizontally in an ash tree which stands in the creek near the right bank about 40 feet below the bridge. The nail is on the side of the tree toward the bridge and is at an elevation of 5.50 feet above the zero of the gage. Bench mark No. 3 is the center of a large wire nail driven horizontally in a small cypress tree on the right bank about 45 feet below the bridge. The nail is on the side of the tree toward the bridge and is at an elevation of 5.50 feet above the zero of the gage. The nails for both bench marks are driven within about one-half inch of the wood, from which the bark has been removed. This station was discontinued on December 31, 1904.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Williamsons Swamp Creek at Davisboro, Ga., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Square feet.	*Feet per sec.*	*Feet.*	*Second-feet.*
June 19	F. A. Murray	104	0.80	2.41	83
July 18	do	123	.81	2.58	100
July 29	M. R. Hall	60	.77	1.64	46
July 29	do	43	1.05	1.64	45
October 13	F. A. Murray	62	.75	1.72	47
October 13	do	64	.64	1.64	41
November 21	do	124	.76	2.58	94
December 28	do	133	.73	2.69	97

Mean daily gage height, in feet, of Williamsons Swamp Creek at Davisboro, Ga., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.70	2.80	2.80	2.50	1.80	3.10	2.20	4.60	2.20	1.65	1.40	2.10
2	2.60	2.90	2.70	2.70	1.80	3.10	1.30	4.60	2.10	1.50	1.40	2.10
3	2.50	2.60	2.60	2.40	1.85	2.30	1.40	2.30	2.00	1.50	2.00	4.00
4	2.40	2.50	3.40	2.25	1.90	1.90	1.30	1.80	2.00	1.80	2.90	3.10
5	2.50	2.60	3.20	2.30	1.55	1.45	1.30	3.80	2.05	1.70	2.90	3.70
6	2.50	2.60	3.10	2.40	1.60	1.40	1.30	3.60	2.05	1.60	2.40	3.40
7	2.50	3.20	4.10	2.45	1.80	1.30	1.30	3.80	2.10	1.60	2.20	3.30
8	2.50	3.10	3.60	2.20	1.90	3.40	1.35	3.85	2.00	1.70	2.10	3.00
9	2.50	3.30	3.40	2.90	1.80	2.00	1.35	5.35	2.00	1.60	2.00	2.90
10	2.50	4.20	3.20	2.70	1.80	1.60	2.70	5.50	2.00	1.45	1.90	2.80
11	2.70	5.10	3.10	2.60	1.80	1.60	2.00	4.00	2.00	1.50	1.80	2.60
12	2.80	3.80	3.10	2.30	1.65	1.60	1.70	2.80	2.00	1.50	1.80	2.60
13	2.60	3.50	2.80	2.25	1.55	1.50	1.50	2.60	2.00	1.40	3.20	2.50
14	2.60	3.70	2.70	2.30	1.45	1.50	1.40	2.40	1.95	1.50	3.60	2.70
15	2.90	3.50	3.20	2.25	1.65	1.50	1.50	2.40	1.90	1.50	3.00	2.70
16	2.70	3.50	2.80	2.20	1.60	1.40	1.35	2.20	1.85	1.50	2.10	3.30
17	2.60	3.30	2.50	2.10	1.50	1.40	1.30	2.05	1.80	1.40	2.20	3.00
18	2.50	3.10	2.40	2.00	1.50	1.40	1.80	2.00	1.80	1.50	2.00	2.80
19	2.60	3.10	2.70	2.10	1.45	1.35	1.60	1.90	1.80	1.50	2.00	2.80
20	2.70	3.10	2.60	2.10	1.40	1.30	1.50	1.80	1.80	1.40	2.00	2.80
21	2.80	3.70	2.90	2.05	1.40	1.30	1.20	1.80	1.70	1.60	2.00	2.70
22	2.90	4.00	2.60	2.00	1.40	1.40	1.40	1.80	1.70	1.50	2.00	2.60
23	4.20	3.70	2.60	2.00	1.25	1.25	1.50	1.90	1.75	1.40	2.60	2.60
24	3.90	3.30	2.60	2.00	1.60	1.20	1.85	1.80	1.80	1.40	2.80	2.70
25	3.00	3.00	3.00	1.90	1.30	1.20	1.45	1.80	1.80	1.40	2.80	2.60
26	2.80	3.10	2.90	2.00	1.25	1.20	2.50	1.70	1.80	1.70	2.60	2.70
27	2.80	3.10	3.40	2.00	1.25	1.20	1.80	5.10	1.70	1.50	2.30	2.50
28	3.00	3.00	3.30	2.00	1.25	1.10	1.60	5.00	1.80	1.40	2.20	2.60
29	3.00	2.90	2.50	1.95	1.30	1.50	2.50	3.60	1.60	1.40	2.20	2.60
30	2.90	.....	2.50	1.90	1.60	1.55	2.25	2.50	1.60	1.40	2.40	3.00
31	2.90	.....	2.60	.....	3.00	.....	2.10	2.30	.....	1.40	.....	2.80

CANNOOCHEE RIVER NEAR GROVELAND, GA.

This station was established June 12, 1903, by F. A. Murray. It is located at Moody's bridge, 3 miles south of Groveland, Bryan County, Ga. The original gage, reading from 0 to 17 feet, is nailed to the right side of the upstream post of the fourth bent from the left bank. From 17 to 20 feet the post is graduated to feet and half feet with nails and brass figures. A new gage consisting of two 5-foot sections of notched gage rod, reading from 0 to 10 feet is fastened with lag screws to the left bank side of upstream post of the third bent from left bank, this being the first bent in water at ordinary stage. A third section of the gage, reading from 5 to 10 feet, is fastened to a gum tree on the left bank 25 feet above the bridge. This gage faces the bridge and is used for the stages which it covers. The observer is J. M. Edwards, who reads the gage once each day. He is paid by the Georgia Geological Survey. Discharge measurements are made from the downstream side of the 9-span wooden highway bridge. The initial point for soundings is the outer edge of the post which supports the

end of the hand rail of the downstream side of the bridge on the left bank. The channel is straight for about 300 feet above and for about 400 feet below the station. The current is swift in the main channel and sluggish near the banks. Both banks are of clay and sand and overflow at from 15 to 16 feet gage height. The bed of the stream is of silt and is shifting. There is but one channel at all stages up to the height at which the river overflows its banks.

Bench mark No. 1 is the top of the bridge floor at the fourth bent from the left end of the bridge on the upstream side opposite a point 61 feet from the initial point for soundings. The point is marked by a cross and the letters B. M. cut in the floor. It is at an elevation of 20.00 feet above the zero of the gage. Bench mark No. 2 is a spike in a pine tree which stands near the upstream side of the road 15 feet from the left end of the bridge and 9 feet upstream from the line of the edge of the bridge. It is at an elevation of 20.12 feet above the zero of the gage. Bench mark No. 3 consists of two large wire nails driven into the tree to which the third section of the gage is fastened at a gage height of 5.30 feet. Two more nails are also driven at the 8-foot mark.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Cannoochee River near Groveland, Ga., in 1903 and 1904.

Date.	Hydrograper.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
June 12	F. A. Murray	132	1,492	2.32	12.90	3,467
June 23	do	101	560	1.31	5.20	734
July 17	do	110	1,077	2.06	9.97	2,224
July 17	do	104	1,049	2.44	9.92	2,562
August 21	do	141	1,821	2.26	15.11	4,125
October 9	do	95	480	.96	4.45	462
November 18	do	96	526	1.39	5.05	734
December 29	do	105	603	1.68	6.20	1,014
1904.						
February 20	F. A. Murray	121	1,069	1.94	9.45	2,075
July 22	M. R. Hall	63	125	.22	1.53	27
July 22[a]	do	33	43	.70	1.61	30
September 12	W. E. Hall	96	428	1.02	4.16	438
September 12	do	96	430	1.01	4.16	435
October 29[a]	B. S. Drane	32	34	.83	1.54	29
October 29[a]	do	32	36	.85	1.54	31
November 29	W. E. Hall	78	237	.38	2.27	91
November 30	do	78	238	.39	2.30	93

[a] Wading 1,000 feet below bridge.

Mean daily gage height, in feet, of Cannoochee River near Groveland, Ga., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	7.2	9.3	9.6	5.9	2.4	2.0	1.7	4.5	6.2	2.1	1.5	2.2
2	7.6	8.5	9.1	5.7	2.4	2.0	1.7	4.6	6.4	2.0	1.5	2.2
3	7.6	8.2	8.2	5.2	2.3	2.0	1.7	5.9	6.2	1.9	1.6	2.1
4	6.9	7.6	8.0	4.7	2.2	2.0	1.7	4.9	4.8	1.9	1.8	2.2
5	6.5	7.0	7.6	4.3	2.2	2.0	1.6	5.9	4.1	1.9	2.1	2.4
6	6.1	6.8	7.6	4.2	2.1	2.0	1.6	8.0	3.8	1.8	2.1	2.4
7	5.7	6.6	7.6	4.0	2.1	1.9	1.6	10.8	5.0	1.8	2.0	2.7
8	5.3	6.2	8.0	4.0	2.1	1.9	1.6	13.2	6.8	1.7	2.0	2.8
9	5.2	6.3	8.0	4.0	2.0	1.9	1.6	14.2	6.0	1.7	2.0	2.9
10	5.1	7.6	8.1	4.4	2.0	1.9	1.6	14.2	4.7	1.7	2.0	2.8
11	4.9	12.5	7.6	4.8	2.0	1.9	1.9	13.7	4.1	1.7	1.9	2.8
12	5.2	14.5	7.7	5.0	2.0	1.8	1.9	11.0	4.1	1.7	1.9	2.8
13	5.2	15.4	7.4	5.2	2.0	1.8	1.9	9.9	3.9	1.6	2.0	2.8
14	5.2	15.3	7.1	5.3	2.0	1.7	2.1	8.9	3.5	1.6	2.5	2.7
15	5.0	14.5	7.1	5.1	2.0	1.7	2.0	7.9	3.2	1.6	2.7	2.6
16	5.0	13.7	6.9	4.8	2.0	1.7	1.8	6.9	3.0	1.6	2.6	2.4
17	5.0	13.7	6.7	4.3	1.9	1.6	1.7	6.0	2.9	1.7	2.5	2.4
18	4.7	11.5	6.4	3.8	1.8	1.6	1.6	5.3	2.8	1.7	2.5	2.5
19	4.5	10.2	6.2	3.5	1.8	1.6	1.6	4.8	2.9	1.7	2.5	2.6
20	4.4	9.5	6.0	3.0	1.7	1.6	1.6	4.6	2.5	1.7	2.5	2.6
21	4.4	9.2	5.8	3.2	1.7	1.7	1.6	4.4	2.4	1.7	2.3	2.4
22	4.0	10.0	5.5	3.4	1.7	1.8	1.5	4.2	2.4	1.6	2.2	2.4
23	5.5	11.5	5.3	3.6	1.7	1.9	1.8	4.0	2.7	1.6	2.2	2.7
24	9.7	12.3	5.2	3.0	1.6	1.9	2.0	3.8	3.0	1.6	2.2	2.9
25	11.6	13.7	5.9	2.8	1.6	1.9	2.2	3.9	2.7	1.6	2.3	2.8
26	12.7	12.5	6.8	2.6	1.6	1.9	2.4	4.2	2.6	1.6	2.4	2.2
27	13.4	11.7	7.2	2.5	1.6	1.9	2.2	4.5	2.5	1.5	2.4	2.2
28	12.2	10.2	8.0	2.5	1.6	1.8	2.0	4.9	2.4	1.5	2.2	2.2
29	11.0	9.8	7.6	2.5	1.9	1.8	2.0	5.2	2.3	1.5	2.2	2.4
30	10.5	.....	6.9	2.3	1.8	1.8	1.9	5.6	2.2	1.5	2.2	2.5
31	9.8	.....	6.3	.....	1.9	.....	2.3	5.9	.....	1.5	.....	2.7

Rating table for Cannoochee River near Groveland, Ga., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.50	30	2.50	120	3.80	360	5.80	882
1.60	36	2.60	134	4.00	405	6.00	940
1.70	42	2.70	149	4.20	453	6.50	1,090
1.80	49	2.80	165	4.40	503	7.00	1,245
1.90	57	2.90	182	4.60	554	7.50	1,405
2.00	65	3.00	200	4.80	606	8.00	1,570
2.10	74	3.10	218	5.00	660	8.50	1,740
2.20	84	3.20	237	5.20	714	9.00	1,915
2.30	95	3.40	276	5.40	769	9.50	2,095
2.40	107	3.60	317	5.60	825	10.00	2,275

The foregoing table is based upon 17 discharge measurements made during 1903–4. It is well defined between gage heights 1.5 feet and 6.2 feet. Above 10 feet the rating curve is a tangent, the difference being 75 per 0.2 feet rise in gage.

Estimated monthly discharge of Cannoochee River near Groveland, Ga., for 1904.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
January	3,550	405	1,317
February	4,300	1,000	2,508
March	2,131	714	1,301
April	911	95	428
May	107	36	60.8
June	65	36	52.2
July	107	30	52.6
August	3,850	360	1,324
September	1,183	84	390
October	74	30	42.0
November	149	30	84.1
December	182	74	122
The year	4,300	30	640

ALTAMAHA RIVER DRAINAGE BASIN.

Altamaha River is formed by the junction of Oconee and Ocmulgee rivers, which unite at the southern boundary of Montgomery County, Ga. Ohoopee River is also a tributary and enters it, from the north side, about 50 miles below the junction of the Oconee and Ocmulgee. The Altamaha River drainage basin is entirely within the State of Georgia. The river rises in the north-central part and flows in a southeasterly direction, emptying into the Atlantic Ocean near Darien. Below the junction of the Oconee and Ocmulgee and for a long distance above, on both rivers, there is no great amount of fall. Steamboat navigation is carried on from Darien to Macon on the Ocmulgee, and to Dublin, and at times to Milledgeville, on the Oconee.

Ohoopee River rises in Washington County and flows in a southeasterly direction to the Altamaha. It flows from the low hills of southeastern Georgia into the flat pine lands. Though it has not so much fall as the more northern streams, it has considerable fall that can be developed into power.

Oconee River rises on the southern slope of the Chattahoochee Ridge, in Hall County, and joins the Middle Oconee on the southwest boundary of Clarke County. From there it flows in a southeasterly direction to the Altamaha. Apalachee River is a large tributary

which rises in Gwinnett and Walton counties and enters the Oconee near the southeastern corner of Morgan County. Little River enters the main stream at the corner of Putnam, Hancock, and Baldwin counties, about 15 miles above Milledgeville, Ga. These tributaries have much fall, and a small part of it is developed. The Oconee has a fall of 250 feet in 45 miles. It has some very large water powers available from its source down to Milledgeville, where it crosses the fall line.

Ocmulgee River, the most westerly of the main tributaries, rises in the north-central part of Georgia on the southern slope of the Chattahoochee Ridge, in Fulton, Dekalb, and Gwinnett counties. It is formed by the junction of Yellow and South rivers just south of the southern corner of Newton County. Yellow River rises in Gwinnett County and flows in a southerly direction into the Ocmulgee. South River rises in Fulton and Dekalb counties and flows in a southeasterly direction. Alcovy River joins the Ocmulgee about 5 miles below the junction of South and Yellow rivers. Towaliga River enters the Ocmulgee at about the southwest corner of Jasper County.

All these tributaries rise in and flow through a very hilly country and have a great deal of fall. Ocmulgee River has a fall of over 210 feet in 35 miles. The last fall of much size is only a few miles above Macon, Ga.

The following pages give the results of data collected in this drainage during 1904:

SOUTH RIVER NEAR LITHONIA, GA.

This station was established August 17, 1903, by F. A. Murray. The station is located a short distance above Albert Shoals, 6 miles south of Lithonia, Ga. The gage is a vertical 10-foot rod fastened to a tree on the right bank just below the bridge. It is read once each day by W. N. New, who is paid by the Georgia Geological Survey. Discharge measurements are made from the 3-span wooden highway bridge. The initial point for soundings is the end of the bridge on the right bank, upstream side. The channel above the station is nearly straight for about 300 feet, and the current is sluggish, being held back by rock ledges below the station. Below the station the channel curves slightly and the current is sluggish for about 400 feet, at which point the shoals begin. The right bank is low and overflows at a gage height of 9 or 10 feet into a second channel, which has a width at high water of about 200 feet. The left bank is high and rocky and does not overflow. The bottom is solid rock.

Bench mark No. 1 is the top of the upstream end of the first wooden floor beam from the right bank. Its elevation is 15.00 feet above the zero of the gage. Bench mark No. 2 is the center of a wire nail driven

horizontally in the upstream side of the base of a willow tree on the left bank about 40 feet upstream from the bridge. Its elevation is 4.00 feet above the zero of the gage. The station was discontinued on December 31, 1904.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of South River near Lithonia, Ga., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
August 17	F. A. Murray	96	294	0.61	3.55	179
September 10	M. R. Hall	102	279	.37	3.43	104
September 10[a]	do	60	81	1.48	3.46	120
October 5	do	100	273	.38	3.40	104
1904.						
January 13	M. R. Hall	103	290	.44	3.58	138
March 7	F. A. Murray	108	382	1.44	4.20	549
March 11	M. R. Hall	97	293	.63	3.67	185
July 16	W. E. Hall	91	216	.26	3.22	56
August 9	F. A. Murray	109	446	2.62	4.90	1,172
August 9	do	109	416	2.24	4.60	934
August 10	do	109	398	2.04	4.53	812
September 23	M. R. Hall	102	250	.22	3.16	55
December 5	do	105	369	1.59	4.28	588

[a] Parkers Bridge, 1 mile above station.

Mean daily gage height, in feet, of South River near Lithonia, Ga., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec
1	3.5	3.6	3.6	3.6	3.6	4.1	3.7	3.6	3.5	3.4	3.3	3.5
2	3.5	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.5	3.4	3.3	3.5
3	3.5	3.6	3.6	3.6	3.6	3.6	3.6	4.3	3.5	3.4	3.3	3.5
4	3.5	3.5	3.7	3.6	3.6	3.5	3.5	3.6	4.2	3.4	3.3	3.5
5	3.5	3.5	3.6	3.6	3.6	3.6	3.5	3.5	3.8	3.4	3.3	4.1
6	3.5	3.6	3.5	3.6	3.5	3.8	3.5	3.7	3.6	3.4	3.3	3.7
7	3.5	3.6	4.2	3.7	3.5	4.4	3.5	5.7	3.6	3.4	3.3	3.6
8	3.5	4.1	4.1	3.7	4.1	3.8	3.5	6.8	3.6	3.4	3.3	3.6
9	3.5	3.7	3.6	3.6	3.7	3.7	3.5	6.5	3.6	3.3	3.3	3.5
10	3.5	4.5	3.6	3.7	3.6	3.6	3.6	4.6	3.6	3.2	3.3	3.6
11	3.5	4.3	3.7	3.6	3.6	3.6	3.5	3.8	3.6	3.3	3.3	3.6
12	3.5	3.7	3.7	3.7	3.6	3.6	3.6	3.7	3.6	3.3	3.3	3.6
13	3.5	3.6	3.6	3.7	3.6	3.6	3.6	3.6	3.5	3.3	3.4	3.7
14	3.5	3.7	4.1	3.6	3.6	3.5	3.6	3.6	3.5	3.3	3.3	3.6
15	3.6	3.7	3.7	3.6	3.6	3.5	3.5	3.7	3.5	3.3	3.3	3.6
16	3.5	3.6	3.7	3.6	3.6	3.5	3.5	4.2	3.5	3.2	3.3	3.6
17	3.7	3.6	3.7	3.6	3.6	3.5	3.5	3.8	3.6	3.2	3.3	3.6
18	3.6	3.7	3.6	3.6	3.6	3.5	3.6	3.6	3.5	3.2	3.3	3.6
19	3.6	3.7	3.6	3.6	3.5	3.5	3.5	4.1	3.5	3.3	3.3	3.5
20	3.6	4.5	3.6	3.6	3.5	3.6	3.5	3.6	3.5	3.3	3.3	3.6
21	3.6	4.1	3.6	3.6	3.5	3.6	3.5	3.6	3.5	3.3	3.3	3.6
22	4.6	4.6	3.7	3.6	3.6	3.8	3.5	3.6	3.5	3.3	3.4	3.6
23	4.2	4.5	3.7	3.6	3.5	3.7	3.7	3.5	3.5	3.3	3.4	3.6
24	4.1	4.3	3.7	3.6	3.5	3.6	3.6	3.5	3.5	3.2	3.4	3.5
25	4.1	3.8	3.7	3.6	3.5	3.6	3.5	3.6	3.5	3.2	3.4	3.6
26	3.6	3.7	3.7	3.7	3.5	3.5	3.5	3.5	3.5	3.2	3.4	3.6
27	3.6	3.7	3.6	3.7	3.5	3.5	3.5	3.6	3.5	3.2	3.4	3.5
28	3.5	3.7	3.6	3.6	3.5	3.8	3.5	3.7	3.4	3.2	3.4	3.9
29	3.5	3.6	3.6	3.6	3.5	3.8	4.5	3.6	3.4	3.2	3.4	3.5
30	3.5	.....	3.6	3.6	3.8	3.8	3.7	3.6	3.4	3.2	3.4	3.6
31	3.5	.....	3.6	.....	4.6	.....	3.5	3.5	.....	3.2	.....	3.6

Rating table for South River near Lithonia, Ga., from August 17, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.20	55	4.10	454	5.00	1,220	5.80	2,050
3.30	77	4.20	530	5.10	1,320	5.90	2,190
3.40	100	4.30	606	5.20	1,420	6.00	2,340
3.50	130	4.40	684	5.30	1,520	6.20	2,660
3.60	168	4.50	764	5.40	1,620	6.40	3,020
3.70	214	4.60	848	5.50	1,720	6.60	3,400
3.80	266	4.70	936	5.60	1,820	6.80	3,800
3.90	322	4.80	1,025	5.70	1,930	7.00	4,200
4.00	384	4.90	1,120				

The above table is based upon 13 discharge measurements made during 1903 and 1904. It is well defined between gage heights 3.2 feet and 5 feet. The table has been extended beyond these limits.

Estimated monthly discharge of South River near Lithonia, Ga., for 1903 and 1904.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
1903.			
August 17–31	454	100	169
September	764	100	167
October	168	130	131
November	848	130	178
December	168	130	135
1904.			
January	848	130	198
February	848	130	318
March	530	130	213
April	214	168	179
May	848	130	189
June	684	130	206
July	764	130	168
August	3,800	130	502
September	530	100	155
October	100	55	74.4
November	100	77	84.7
December	606	130	186
The year	3,800	55	206

OCMULGEE RIVER NEAR FLOVILLA, GA.

A station was established July 26, 1901, on Ocmulgee River at Lamar's ferry, one-half mile below Lamar's mill and 5 miles east of Flovilla, Ga. The object of this station was to compare the discharge of the river at this point with its discharge below at Macon through the low-water season.

The gage consisted of a $\frac{1}{4}$ by 5 inch by 10 foot poplar board, graduated to feet and tenths with brass figures, staples, and tacks. The rod was nailed to a 16-foot pine plank, which was spiked to an ash tree 25 feet below the ferry landing. The tree was graduated with nails 1 foot apart, extending the gage up to 20 feet above datum.

The gage and bench marks were washed away by a flood on February 27, 1902. The station was reestablished June 18, 1903, at Lamar's ferry, by M. R. Hall. The vertical timber gage is in three sections. The first section is a 1 by 4 inch board, reading from 0 to 5 feet, nailed to a 2 by 6 inch scantling which is spiked to a willow tree at the mouth of a small branch about 20 feet above the ferry landing on the right bank. The second section, reading from 5 to 15 feet, is nailed to an ash tree about 60 feet from the river up the same branch.

The third section, reading from 15 to 25 feet, is attached to a cottonwood tree on bank of same branch about 200 feet from the river. No attempt was made to place this gage on the same datum of the old one. The observer is B. S. White, who reads the gage once each day. He is paid by the Georgia Geological Survey. Measurements are made from the ferryboat. The initial point for soundings is the windlass on the right bank. The channel is straight for 1,000 feet above and 5,000 feet below the station. The current is swift and regular; the right bank is high, but overflows at extreme high water. The left bank is somewhat lower. The bed of the stream is sandy and shifting, and there is but one channel.

Bench mark No 1 is a nail driven in a large cottonwood tree about 200 feet from the river on the branch on which the gage is located. Its elevation is 14.00 feet above the zero of the gage. Bench mark No. 2 is a cross in the solid rock, 100 feet uphill from the first bench mark and 140 feet north from the wagon road, at a point 250 feet west of the ferry. Its elevation is 34.24 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Ocmulgee River near Flovilla, Ga., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-f*
August 25	F. A. Murray	206	484	1.84	1.61	89
September 29	do	207	404	1.90	1.35	77
October 13	J. M. Giles	208	414	1.69	1.10	70
November 12	M. R. Hall	210	535	2.00	1.78	1,07
December 19	J. M. Giles	215	542	1.62	1.61	87
1904.						
January 13	W. E. Hall	213	593	1.90	1.97	1,13
January 21	do	208	504	1.99	1.85	1,00
January 22	do	220	1,207	2.87	5.50	3,45
February 16	F. A. Murray	212	764	2.28	2.93	1,74
April 15	W. E. Hall	211	512	1.89	1.67	97
May 28	do	200	319	1.60	.50	51
June 17	B. S. Drane	197	305	1.52	.47	46
July 12	do	209	529	1.68	1.39	89
August 26	do	212	724	2.00	2.36	1,45
September 20	J. M. Giles	186	227	1.46	— .03	33
October 6	do	196	230	1.31	— .21	30
November 2	B. S. Drane	205	260	1.57	.03	40
December 21	W. E. Hall	208	434	1.70	.93	74

Mean daily gage height, in feet, of Ocmulgee River near Florilla, Ga., for 1904.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.7	0.7	−0.3	−0.3	0.6	17	4.0	0.0	−0.6	0 6	1.0
2	2.7	.7	− .3	− .2	.6	18	2.7	.0	− .6	.5	1.0
3	2.2	.3	− .3	.2	.8	19	1.7	.0	− .4	.4	1.0
4	3.2	.4	− .5	.7	1.2	20	1.5	− .1	− .4	.4	.9
5	1.5	3.7	− .3	.9	1.8	21	1.1	− .1	− .3	.2	1.0
6	1.0	2.3	− .3	.7	4.0	22	1.2	− .1	− .3	.5	.9
7	4.2	1.4	− .3	.6	3.8	23	.9	.4	− .3	.9	.9
8	7.4	1.0	− .3	.4	3.0	24	1.3	.0	− .4	.5	.8
9	10.5	.8	− .3	.3	2.0	25	.9	− .2	− .6	.4	.8
10	11.0	.5	− .4	.1	2.8	26	2.4	− .3	− .6	.8	.7
11	7.6	.4	− .5	.1	1.4	27	1.5	− .3	− .2	.7	1.0
12	5.0	.3	− .3	.1	1.5	28	1.4	− .2	− .2	.4	3.5
13	4.0	.4	− .3	.6	1.3	29	2.2	− .1	− .2	.6	3.5
14	3.9	.3	− .3	1.1	1.0	30	1.1	− .2	− .1	.5	3.0
15	2.0	.2	− .4	1.0	1.0	31	.9	.....	− .3	.....	1.9
16	4.1	.2	− .4	.8	.9						

Rating table for Ocmulgee River near Flovilla, Ga., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
- 0.50	225	0.70	560	1.90	1,070	4.20	2,490
− .40	250	.80	595	2.00	1,120	4.40	2,640
− .30	275	.90	630	2.20	1,225	4.60	2,790
− .20	300	1.00	670	2.40	1,335	4.80	2,940
− .10	325	1.10	710	2.60	1,450	5.00	3,090
.00	350	1.20	750	2.80	1,570	5.50	3,475
.10	375	1.30	790	3.00	1,690	6.00	3,875
.20	400	1.40	835	3.20	1,820	6.50	4,275
.30	430	1.50	880	3.40	1,950	7.00	4,675
.40	460	1.60	925	3.60	2,080	7.50	5,085
.50	490	1.70	970	3.80	2,210		
.60	525	1.80	1,020	4.00	2,350		

The above table is based upon discharge measurements made during 1903 and 1904. It is well defined between gage heights 0 feet and 6 feet. The table has been extended beyond these limits. Above 7 feet gage height estimates have been made from logarithmic diagram.

Estimated monthly discharge of Ocmulgee River near Florilla, Ga., for 1904.

[Drainage area, 1,500 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches
August	8,100	630	2,005	1.34	1.54
September	2,145	275	507	.338	.377
October	325	200	261	.174	.201
November	710	275	493	.329	.367
December	2,350	525	987	.658	.759

OCMULGEE RIVER AT MACON, GA.

Ocmulgee River rises in the north-central part of Georgia and flows in a southeasterly direction, joining the Oconee south of Mount Vernon to form Altamaha River. The drainage area has the same general features as that of the Oconee. A station was established at Macon, Ga., January 21, 1893, by the United States Weather Bureau. Discharge measurements were begun by the United States Geological Survey in 1895, and a wire gage was established on the bridge of the Macon, Dublin and Savannah Railroad, and was set on the same datum as the Weather Bureau gage. For a time gage-height records were maintained by the Geological Survey, as the Weather Bureau records were for a part of the year only and were discontinued altogether from June 30, 1897, to June 1, 1899. Since June 1, 1899, the Weather Bureau gage-height records have been taken continuously, and have been furnished to the Geological Survey.

The gage is a heavy timber graduated to feet and tenths by copper nails and is bolted to the downstream portion of the right bank stone pier of the Central of Georgia Railroad bridge. Discharge measurements are made from the downstream side of the Fifth Street Bridge, an iron bridge of two 190-foot spans, located about 500 feet above the railroad bridge to which the gage is attached. The initial point for soundings is the end of the iron hand rail of the footway at the right bank on the downstream side. The channel is straight and without obstructions, except one bridge pier. The banks are high and not subject to overflow. The bed of the river is soft and changeable. The station was a fairly good one until the spring of 1902, when the bed of the stream (which is of shifting sand) below the station changed to such an extent as to make the current very sluggish at low stages.

Bench mark No. 1 is the top of the iron rim of the sidewalk 80 feet from the initial point for soundings. Its elevation is 34.35 feet above

the zero of the gage. It was determined by measuring down to the water surface. Bench mark No. 2 is the top of a cast-iron post at the end of the hand rail on the right bank, downstream side, of the Fifth Street Bridge. Its elevation is 37.37 feet above the zero of the gage. Bench mark No. 3 is the top of the downstream side of the capstone of the right bank abutment of the Central of Georgia Railroad bridge. Its elevation is 32.30 feet above the zero of the gage. Bench mark No. 4 is an aluminum tablet on the wall at the west side of the door of the United States Government building at the Mulberry street front. This bench mark is marked 334 feet and has an elevation of 64.37 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Ocmulgee River at Macon, Ga., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
January 26	M. R. Hall		2,337	0.77	4.00	1,794
April 2	J. M. Giles		4,720	1.56	11.30	7,244
April 4	do		4,006	1.28	9.00	5,118
April 21	E. C. Murphy		3,652	1.20	7.88	4,385
July 14	M. R. Hall		4,368	1.76	11.00	7,676
July 14	F. A. Murray		4,368	1.65	11.00	7,314
August 24	do		2,115	.65	3.61	1,382
September 30	do		1,765	.57	2.55	1,022
September 30	do		1,765	.60	2.56	1,057
October 15	J. M. Giles		541	1.71	2.22	926
October 15	do		1,683	.54	2.28	915
November 13	M. R. Hall		1,891	.65	2.84	1,236
December 21	J. M. Giles		1,877	.67	2.88	1,264
December 21	do		1,923	.69	2.95	1,329
1904.						
February 17	F. A. Murray	262	2,280	.97	4.35	2,232
April 11	W. E. Hall	271	2,060	.85	3.52	1,759
May 24	do	218	1,424	.49	1.38	703
May 27	do	223	1,426	.44	1.29	625
July 20	M. R. Hall	252	1,576	.64	1.87	1,011
August 19	W. E. Hall	255	1,833	.86	3.31	1,584
September 20[a]	J. M. Giles	148	279	1.54	.30	431
October 6[b]	do	59	137	1.70	— .20	232
November 1[b]	B. S. Drane	63	140	2.16	— .14	302

[a] At shoals above bridge. [b] Boat at Second street.

Mean daily gage height, in feet, of Ocmulgee River at Macon, Ga., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.5	3.5	4.2	3.1	2.8	3.9	1.9	3.5	1.8	0.0	0.0	1.0
2	2.5	3.5	4.1	3.0	2.8	4.8	1.9	2.3	1.7	— .3	— .1	1.1
3	2.1	3.6	4.2	3.1	2.8	3.4	2.0	2.9	1.4	a— .5	.2	2.4
4	2.8	3.3	4.4	3.0	2.7	3.3	1.2	4.4	1.0	a— .8	.7	1.8
5	2.7	3.2	4.2	2.9	2.7	1.9	.9	5.3	1.0	a—1.0	1.6	2.0
6	2.6	3.1	3.8	2.8	2.6	1.7	1.7	3.4	4.7	— .2	1.5	5.1
7	2.4	3.2	6.1	3.0	2.5	1.5	1.2	2.4	3.0	.2	1.4	6.0
8	2.4	8.3	7.3	3.2	2.6	2.0	1.2	10.0	2.0	.1	.9	4.4
9	2.6	7.5	7.1	5.7	3.6	4.3	1.0	11.1	1.6	.0	.9	3.3
10	2.7	6.5	5.7	5.1	3.3	3.3	.7	15.4	1.5	— .1	.8	2.5
11	3.1	10.3	5.1	3.9	3.7	2.0	1.0	13.0	1.4	.0	.8	2.3
12	3.3	9.7	4.6	3.1	3.0	1.5	1.0	9.7	1.3	— .1	.5	2.0
13	3.2	7.9	4.2	3.2	2.8	1.3	1.9	6.7	1.3	— .1	.9	2.0
14	3.2	6.1	4.1	3.1	2.7	1.1	1.7	3.7	1.1	.1	1.3	1.9
15	3.3	5.2	4.2	3.0	2.6	1.0	1.7	6.7	1.0	— .1	1.8	1.9
16	3.2	4.8	5.0	2.9	2.5	1.0	1.2	5.4	1.0	— .2	1.8	2.9
17	3.5	4.5	4.3	3.0	2.4	.9	1.0	5.3	.9	— .3	1.3	1.9
18	4.5	4.2	3.9	2.8	2.3	.9	1.1	4.9	.8	— .1	1.0	2.0
19	4.2	3.8	3.7	2.8	2.2	1.1	1.4	3.5	.8	— .3	.9	1.8
20	3.5	4.1	3.7	3.0	2.1	.9	1.9	2.5	.7	— .3	1.0	1.8
21	3.2	5.8	3.6	3.0	2.0	.8	1.3	2.0	.5	.0	.9	1.7
22	3.1	7.0	3.4	2.9	1.9	4.3	1.3	1.8	1.7	— .3	.9	1.5
23	12.9	10.3	3.6	2.9	1.8	3.4	1.1	1.7	.6	— .2	1.0	1.4
24	10.2	9.3	3.9	2.9	1.7	2.0	1.4	1.7	.9	.4	1.5	1.4
25	6.9	7.2	4.0	2.9	1.6	1.4	2.7	7.0	.6	.2	2.1	1.5
26	5.0	5.4	3.7	2.8	1.6	1.0	2.2	5.3	.4	.3	1.8	1.7
27	4.3	5.2	3.6	2.8	1.5	.8	1.2	6.3	.3	.3	1.3	2.0
28	3.8	4.7	3.8	3.0	1.4	.8	1.1	4.8	.3	.2	1.2	6.4
29	3.7	4.3	4.3	3.0	1.3	1.3	.8	3.3	.2	.0	1.0	5.5
30	3.6	.....	3.2	2.9	1.3	3.0	1.7	2.9	1	.1	1.0	4.7
31	3.5	.....	3.0	.....	1.8	.....	4.6	2.0	.....	— .1	.....	3.7

a See footnote to estimated monthly discharge.

Rating table for Ocmulgee River at Macon, Ga., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
—0.30	250	0.70	480	1.70	810	3.40	1,660
— .20	270	.80	510	1.80	850	3.60	1,770
— .10	290	.90	540	1.90	895	3.80	1,890
.00	310	1.00	570	2.00	940	4.00	2,010
.10	330	1.10	600	2.20	1,030	4.20	2,130
.20	350	1.20	630	2.40	1,130	4.40	2,250
.30	375	1.30	665	2.60	1,230	4.60	2,370
.40	400	1.40	700	2.80	1,330	4.80	2,490
.50	425	1.50	735	3.00	1,440	5.00	2,610
.60	450	1.60	770	3.20	1,550		

The foregoing table is based upon 9 discharge measurements made during 1904. It is well defined between gage heights —0.3 foot and 5 feet. For gage heights above 5 feet the discharge has been estimated from 1903 measurements.

Estimated monthly discharge of Ocmulgee River at Macon, Ga., for 1904.

[Drainage area, 2,425 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	9,480	985	2,064	0.851	0.981
February	6,540	1,495	3,149	1.30	1.40
March	4,100	1,440	2,214	.913	1.05
April	3,050	1,330	1,535	.633	.706
May	1,830	665	1,120	.462	.533
June	2,490	510	1,029	.424	.473
July	2,370	480	772	.318	.367
August	12,600	810	2,967	1.22	1.41
September	2,430	330	671	.277	.309
October[a]	400	250	300	.124	.143
November	985	290	602	.248	.277
December	3,505	570	1,295	.534	.616
The year	12,600	250	1,476	.609	8.26

[a] Gage heights from October 3 to 5 are considered too low to represent the true mean. The minimum discharge for the month has been assumed to apply for those days.

ALCOVY RIVER NEAR COVINGTON, GA.

This station was established on April 30, 1901. It is located about 3 miles east of Covington, at a low wooden bridge which is often under water. The gage is a vertical rod 10 feet long, graduated to feet and tenths, marked by V-shaped grooves cut into the face of rod and brass figures. It is spiked to a birch tree on the left bank of the river 2 feet from the upstream side of the bridge. The observer is Stephen Belcher, a farmer living near, who is paid by the Georgia Geological Survey. Discharge measurements are made from the upstream side of a low, two-span, wooden bridge about 100 feet long. The initial point for soundings is the end of the bridge floor on the left bank, upstream side. The banks are low and liable to overflow. The ground on the right bank is low and swampy for several hundred yards and is flooded by a moderate rise. The bed of the stream is sandy and shifting, and the water is sluggish at low stages.

Bench mark No. 1 is a notch and nail in a maple tree on the right bank, about 15 feet from the upper side of the bridge. Its elevation is 5.91 feet above the zero of the gage. Bench mark No. 2 is a copper

plug set in the solid rock on the north edge of the side ditch on the upstream side of the road, 100 feet from the end of the bridge, on the left bank of the river. Its elevation is 7.82 feet above the zero of the gage. This station was discontinued on December 31, 1904.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Alcovy River near Covington, Ga., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
March 11	M. R. Hall		518	1.11	4.41	575
May 28	do		465	.83	3.48	385
July 24	do		352	.49	1.92	174
August 27	do		334	.38	1.60	127
October 8	do		306	.39	1.50	120
November 14	F. A. Murray		334	.47	1.90	157
December 19	do		344	.45	1.85	155
1904.						
February 20	W. E. Hall	71	470	.88	3.67	415
April 13	M. R. Hall	60	320	.63	2.11	202
June 16	do	59	230	.29	.63	68
July 12	W. E. Hall	57	254	.37	1.00	94
September 22	M. R. Hall	60	207	.26	.45	53
September 22 [a]	do	24	26	1.61	.45	42
September 22 [b]	do	30	33	1.27	.45	42
December 6	do	67	392	.84	3.35	328
December 6	do	67	396	.90	3.38	358

[a] 200 feet below bridge. [b] 300 feet above bridge.

Mean daily gage height, in feet, of Alcovy River near Covington, Ga., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.00	2.60	2.90	2.40	2.10	2.90	1.25	0.80	1.15	0.25	0.55	1.10
2	2.90	2.50	2.80	2.40	1.90	2.40	1.15	1.20	1.00	.45	.65	1.40
3	2.00	2.40	2.90	2.50	1.80	2.30	.80	3.65	.80	.30	.80	1.50
4	2.20	2.30	3.00	2.40	1.70	1.50	.60	1.85	1.30	.20	1.30	1.70
5	2.40	2.20	2.90	2.00	1.70	1.30	.60	1.45	2.50	.20	1.45	2.50
6	2.30	2.20	2.60	2.00	1.70	1.50	.50	1.30	1.70	.20	1.55	3.40
7	2.20	2.50	1.00	2.50	1.50	1.40	.40	2.80	1.15	.35	1.35	3.45
8	2.10	2.70	4.50	3.00	2.50	1.50	.75	3.10	1.00	.30	.95	3.40
9	2.20	2.80	4.90	3.70	2.20	1.50	1.75	4.40	1.10	.35	.95	2.40
10	2.20	3.50	4.60	2.90	2.60	1.50	1.70	4.80	1.00	.30	.90	2.30
11	2.30	5.50	4.00	2.50	2.90	1.30	1.65	5.70	1.00	.30	.85	2.20
12	2.50	5.00	3.30	2.30	2.00	1.20	1.60	5.90	.75	.30	.85	2.25
13	2.40	4.50	3.00	2.10	1.90	1.10	1.00	4.75	.80	.25	1.50	2.00
14	2.60	4.10	3.00	2.00	1.40	1.00	1.20	3.30	.75	.25	1.45	1.95
15	2.30	3.80	3.50	2.00	1.40	.90	.90	3.10	.75	.25	1.30	1.70
16	2.10	3.60	3.60	2.00	1.50	.80	.75	4.90	.70	.25	1.35	1.70
17	2.50	3.20	3.20	2.00	1.40	.60	.70	4.75	.50	.25	1.20	1.80
18	2.70	3.00	3.00	2.00	1.50	.60	.50	2.80	.65	.25	1.10	1.70
19	2.60	3.40	2.80	2.00	1.30	.50	.60	2.00	.60	.25	1.05	1.70
20	2.40	3.70	2.50	2.00	1.30	.40	.70	1.80	.50	.30	1.10	1.60
21	3.40	4.20	2.50	2.10	1.30	.40	.90	1.70	.45	.25	1.15	1.60
22	3.50	4.70	2.90	2.10	1.30	.70	.50	1.40	.40	.25	1.10	1.50
23	4.50	5.00	3.10	2.00	1.20	.60	.70	1.20	.30	.25	1.60	1.50
24	4.10	4.70	3.10	2.10	1.20	.50	.80	1.20	.30	.25	1.80	1.50
25	3.50	4.40	2.90	2.00	1.10	.50	.70	1.20	.50	.90	2.15	1.75
26	3.00	3.90	2.80	2.20	1.10	.50	.60	1.10	.45	.85	2.00	1.85
27	2.90	3.40	2.80	2.20	1.10	.45	.50	1.15	.40	.75	1.50	1.80
28	2.70	3.20	2.70	2.20	1.10	.40	.40	1.70	.35	.65	1.30	2.10
29	2.60	3.00	2.50	2.00	1.00	.75	.60	1.40	.30	.65	1.20	2.60
30	2.50	.....	2.30	1.90	1.00	1.30	.50	1.25	.30	.65	1.20	2.90
31	2.90	.....	2.30	.....	2.00	.....	.70	1.10	.....	.65	.....	2.75

Rating table for Alcovy River near Covington, Ga., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.20	38	1.50	135	2.70	259	3.90	460
.30	45	1.60	144	2.80	272	4.00	480
.40	52	1.70	153	2.90	286	4.20	522
.50	59	1.80	162	3.00	300	4.40	564
.60	66	1.90	171	3.10	315	4.60	606
.70	73	2.00	180	3.20	331	4.80	648
.80	80	2.10	190	3.30	347	5.00	690
.90	87	2.20	201	3.40	364	5.20	734
1.00	95	2.30	212	3.50	382	5.40	778
1.10	103	2.40	223	3.60	401	5.60	822
1.20	111	2.50	234	3.70	420	5.80	866
1.30	119	2.60	246	3.80	440	6.00	910
1.40	127						

The foregoing table is based upon nine discharge measurements made during 1904. It is well defined between gage heights 0.0 and 4 feet. Above 4 feet the curve is determined by two measurements made in 1902 and 1903.

Estimated monthly discharge of Alcovy River near Covington, Ga., for 1904.

[Drainage area, 228 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	585	180	264	1.16	1.34
February	800	201	406	1.78	1.92
March	669	212	331	1.45	1.67
April	420	171	209	.917	1.02
May	286	95	147	.645	.744
June	286	52	105	.460	.513
July	157	52	84.2	.369	.425
August	888	80	290	1.27	1.46
September	234	45	80.8	.354	.395
October	87	38	50.6	.222	.256
November	195	63	115	.504	.562
December	373	103	193	.846	.975
The year	888	38	190	.831	11.28

APALACHEE RIVER NEAR BUCKHEAD, GA.

This station was established February 13, 1901, by M. R. Hall. It is located at the iron wagon bridge over Apalachee River about 3½ miles north of the town of Buckhead, Ga. The bridge is a single span 103 feet long, supported by tubular piers. Its trestle approaches are about 500 feet long on the right bank and about 100 feet on the left. At ordinary stages the channel is about 80 feet wide, and it is only slightly curved above and below the bridge. The bed of the river is part rock and part sand. The current is moderately swift and is somewhat broken and irregular on account of ruins of old pier bases about 50 feet upstream. The right bank is low for a distance of 400 feet and will overflow at a gage height of 10 feet. The low portion is thickly covered with trees and a brushy growth, which will greatly retard the flood water passing over it. The left bank is high and will not overflow, except to a short distance up the steep slope. Measurements are made from the downstream side of the bridge, and the initial point is the outside edge of the iron pier, left bank, downstream. The original gage was graduated to feet and tenths with brass figures and staples, and consisted of two parts. The first section, extending from zero to 10 feet, was fastened to a small ash tree

on the left bank about 100 feet below the bridge. The second section, extending from 6 to 20 feet, was nailed to the upstream post of the last wooden bent next to the iron bridge, on the right bank.

On March 22, 1905, a standard chain gage was attached to the upstream side of the bridge, in the third panel from the right bank. The length of the chain from the end of the weight to the marker is 30.70 feet.

Bench mark No. 1 is the top of the iron pier from the right bank, downstream side. Its elevation is 25.00 feet above the zero of the gage. Bench mark No. 2 is the top of the downstream end of the first floor beam from the right bank. Its elevation is 25.50 feet above the zero of the gage. Bench mark No. 3 is a copper plug set in solid rock 10 feet west of the upstream tubular pier on right bank and 3 feet upstream from the line of the upper edge of the bridge. Its elevation is 3.73 feet above the zero of the gage.

The observer is G. A. J. Adams, a farmer living about one-third of a mile from the bridge. Readings are made once a day, except for three months during low water, when they were made twice a day. The observer is paid by the Georgia Geological Survey.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Apalachee River near Buckhead, Ga.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
January 15	M. R. Hall		290	1.53	2.33	444
May 27	do		222	1.63	1.88	361
June 12	do		327	1.97	3.07	643
July 25	do		204	1.30	1.51	266
August 28	do		198	1.08	1.31	214
October 9	do		211	1.12	1.45	237
December 1	do		231	1.10	1.60	255
1904.						
March 19	M. R. Hall	85	279	1.67	2.39	466
May 12	do	73	260	1.20	1.83	311
July 13	W. E. Hall	75	244	.91	1.48	223
August 9	M. R. Hall	95	771	2.43	7.15	1,877
August 9	do	95	785	2.42	7.30	1,903
September 21	do	73	180	.70	.90	128
October 13	W. E. Hall	70	166	.55	.80	91
October 13	do	70	166	.57	.80	94
November 26	M. R. Hall	77	232	.80	1.39	186
November 26	do	77	227	.74	1.34	167

Mean daily gage height, in feet, of Apalachee River near Buckhead, Ga., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.80	1.90	2.40	2.20	1.90	2.30	2.00	1.70	1.50	0.65	0.95	1.40
2	1.80	1.80	2.50	2.40	1.50	2.10	1.80	1.90	1.50	.65	1.25	1.50
3	1.90	1.80	2.50	2.20	1.80	1.50	1.30	2.10	1.40	a.50	1.20	1.90
4	1.80	1.90	2.40	2.10	1.90	1.30	1.40	3.00	1.60	.65	1.90	1.65
5	1.70	2.00	2.30	2.00	1.60	1.50	1.30	2.70	2.80	.65	1.85	2.25
6	1.70	2.10	2.40	2.00	1.70	1.40	1.20	2.40	2.30	.65	1.50	2.75
7	1.60	2.10	3.60	2.20	1.80	1.30	1.10	3.00	1.90	.75	a1.00	3.55
8	1.60	3.10	5.70	2.80	1.90	2.90	1.00	4.50	1.70	.80	1.45	2.65
9	1.50	4.00	4.80	4.00	2.00	2.40	3.00	5.70	1.60	.65	1.40	2.15
10	1.80	4.50	3.40	2.90	2.50	1.90	1.90	9.90	1.40	a.45	1.25	1.90
11	1.90	7.00	3.00	2.40	2.10	1.60	1.80	6.70	1.30	.65	1.35	1.80
12	1.90	6.50	2.80	2.30	2.00	1.60	1.70	6.40	1.30	.65	1.35	1.80
13	2.00	5.50	2.50	2.30	1.80	1.50	1.60	2.50	1.40	.60	1.90	1.75
14	2.00	3.10	2.30	2.20	1.70	1.50	1.50	2.60	1.40	.60	1.80	1.70
15	2.00	3.00	3.50	2.10	1.90	1.40	1.40	2.80	1.30	.65	1.85	1.70
16	2.00	2.80	3.30	2.00	1.80	1.40	1.20	3.50	1.20	.65	1.75	1.80
17	2.20	2.40	2.80	1.90	1.80	1.30	1.00	4.50	1.00	a.45	1.70	1.80
18	2.10	2.20	2.60	2.00	1.80	1.30	.80	2.60	.85	.55	1.70	2.00
19	2.10	2.50	2.40	2.10	1.70	1.00	1.00	2.80	a.65	.65	1.65	1.80
20	2.00	3.30	2.30	2.20	1.70	.70	1.20	2.00	.80	.65	1.45	1.90
21	2.10	4.00	2.20	2.30	1.60	2.00	1.00	1.70	.80	.65	a1.00	1.80
22	2.20	5.10	3.60	2.20	1.50	1.70	1.60	1.50	.80	.65	1.45	1.70
23	6.00	6.80	3.20	2.10	1.50	1.50	1.60	2.00	.75	.60	1.75	1.70
24	6.50	5.00	3.10	2.00	1.40	1.40	2.00	2.10	.75	a.40	1.65	1.60
25	2.70	3.50	2.90	1.90	1.40	1.30	1.20	2.30	.75	.70	1.70	1.70
26	2.50	3.00	2.70	2.10	1.40	1.30	1.60	2.00	a.55	.85	1.50	1.60
27	2.40	2.80	3.00	2.20	1.30	1.20	1.50	1.70	.60	1.40	1.45	1.60
28	2.40	2.60	2.70	2.30	1.30	1.20	1.50	2.00	1.05	1.05	a1.25	3.00
29	2.30	2.50	2.50	2.20	1.30	1.60	1.60	1.70	.90	.90	1.50	3.20
30	2.00	.....	2.40	2.10	1.20	2.50	1.60	1.60	.75	.95	1.45	2.50
31	2.00	.....	2.30	.....	1.80	.....	1.50	1.60	.....	a.65	.....	2.20

a During low water in September, October, and November the Monday gage heights are lower than natural flow on account of storing water during Sunday at High Shoals Factory 25 miles above this station.

Rating table for Apalachee River near Buckhead, Ga., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.40	43	1.20	174	2.00	358	3.60	791
.50	55	1.30	195	2.20	409	3.80	849
.60	69	1.40	216	2.40	461	4.00	907
.70	84	1.50	238	2.60	514	4.20	965
.80	100	1.60	261	2.80	568	4.40	1,025
.90	117	1.70	284	3.00	622	4.60	1,085
1.00	135	1.80	308	3.20	678	4.80	1,145
1.10	154	1.90	333	3.40	734	5.00	1,205

The above table is based upon 26 discharge measurements made during 1901–1904. It is well defined between gage heights 0.8 foot and 3 feet and fairly well from gage

heights 3 to 8 feet. Above gage height 4.2 feet the rating curve is a tangent, the difference being 30 per tenth.

Estimated monthly discharge of Apalachee River near Buckhead, Ga., for 1904.

[Drainage area, 440 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	1,655	238	438	0.995	1.15
February	1,805	308	751	1.71	1.84
March	1,415	409	596	1.35	1.56
April	907	333	425	.966	1.08
May	487	174	286	.650	.749
June	595	84	264	.600	.669
July	622	100	239	.543	.626
August	2,675	238	647	1.47	1.70
September	568	[a]62	187	.425	.474
October	216	[a]43	84.1	.191	.220
November	333	[a]126	240	.545	.608
December	776	216	363	.825	.951
The year	2,675	43	377	.856	11.00

[a] See note under gage heights.

OCONEE RIVER NEAR GREENSBORO, GA.

This station was established July 25, 1903, by M. R. Hall. It is located at the new wagon bridge, about 5 miles west of Greensboro, on the road to Madison, Ga. The bridge is of two spans. The first one from the right bank is 80 feet long, and is not over the water except at time of floods. The main span over river is 144 feet long. There is also 52 feet of iron trestle and about 40 feet of wooden trestle on the right bank, and 253 feet of iron trestle and about 325 feet of wooden trestle on the left bank. Ordinarily the river is about 120 feet wide. The bed is sandy and shifting. The channel is nearly straight, and the current is regular and sluggish at low stages. The right bank is high and rocky, with the exception of a low bench under the bridge and approach. The left bank is low and will overflow at a gage height of 12 to 15 feet to the end of the approach, a distance of about 600 feet, and extreme high water may pass beyond the end of the approach.

Discharge measurements are made from the downstream side of the bridge. The initial point is the end of the iron trestle on the right bank, downstream.

The boxed chain gage is bolted to the lower chord of the downstream side of the bridge 163 to 165 feet from the initial point for soundings. The length of the chain from the end of the weight to the marker is 38.73 feet. The gage is read once each day by M. A. Stevens, who is paid by the Georgia Geological Survey.

Bench mark No. 1 is the top of the downstream end of the second floor beam from the right-bank pier. Its elevation is 36.00 feet above gage datum. Bench mark No. 2 is a copper plug set in the rock under the upstream side of the bridge opposite a point 84 feet from the initial point for soundings. Its elevation is 13.55 feet above gage datum. Bench mark No. 3 is on a hickory tree 26 feet downstream from the end of the wooden trestle on the right bank. Its elevation is 33.15 feet above gage datum. Bench mark No. 4 is the concrete foundation under the iron post below the initial point for soundings. Its elevation is 27.58 feet above gage datum.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Oconee River near Greensboro, Ga., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet*
June 12	M. R. Hall		808	1.88	4.00	1,521
July 25	do		439	1.67	1.75	733
August 28	do		439	1.51	1.70	665
October 9	do		424	1.63	1.70	690
December 2	W. E. Hall		389	1.86	1.66	725
1904.						
February 19	W. E. Hall	117	525	2.03	2.75	1,066
March 19	M. R. Hall	117	544	1.86	2.75	1,023
May 12	do	113	404	1.86	1.90	753
June 9	do	115	368	1.68	1.57	617
July 13	W. E. Hall	115	326	1.40	.99	455
August 9	M. R. Hall	131	1,409	3.56	9.82	5,017
August 9	do	133	1,504	3.61	10.49	5,435
September 21	do	94	295	1.01	.45	297
September 21	do	94	291	1.03	.45	301
October 13	W. E. Hall	93	285	1.06	.51	302
October 13	do	93	285	1.02	.50	291
November 26	M. R. Hall	103	320	1.63	1.35	523
November 26	do	103	308	1.60	1.28	494

Mean daily gage height, in feet, of Oconee River near Greensboro, Ga., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.8	2.0	3.1	2.6	1.8	3.1	2.5	2.6	1.5	0.4	0.7	1.4
2	1.8	2.2	2.8	2.6	1.8	2.6	1.7	2.7	1.5	.3	.8	1.4
3	2.0	2.3	3.0	2.4	1.7	2.0	1.5	2.4	1.7	.3	.8	1.8
4	1.8	2.4	3.4	2.3	1.5	1.4	1.0	2.0	2.0	.4	1.2	1.7
5	1.8	2.5	3.4	2.3	1.5	1.2	.9	1.4	3.8	.6	1.3	1.9
6	1.6	2.5	3.4	2.2	1.6	1.0	.9	3.4	2.8	.5	1.0	4.4
7	1.7	2.3	6.0	2.7	1.6	1.0	.8	3.2	1.9	.4	.9	4.7
8	1.8	5.1	7.9	2.8	1.6	1.8	.8	3.7	1.8	.4	.9	2.8
9	1.8	5.5	7.6	3.8	1.7	1.3	1.1	9.3	1.2	.3	.7	2.2
10	1.9	4.0	4.3	3.0	1.8	1.2	1.0	11.9	1.0	.2	.6	1.9
11	2.0	3.5	3.8	2.5	4.5	1.1	1.7	10.0	1.0	.6	.6	2.0
12	2.0	6.2	3.6	2.4	2.0	2.3	1.5	5.3	.9	.6	.6	2.0
13	2.1	4.2	3.4	2.2	2.0	1.3	1.1	3.8	.9	.5	1.6	1.8
14	2.0	3.9	3.1	2.1	1.8	1.2	.9	2.8	.9	.5	1.4	1.7
15	2.0	3.3	4.8	2.2	1.8	1.1	.8	2.4	.8	.2	1.2	1.7
16	1.9	3.2	3.5	2.1	1.7	.9	.7	3.9	.7	.1	1.2	1.5
17	2.5	2.8	3.2	2.2	1.8	.9	.7	2.7	.7	.2	1.2	1.8
18	2.0	2.7	2.8	2.2	1.6	1.0	.7	2.1	.6	.2	1.1	1.8
19	2.0	3.0	2.7	2.3	1.5	.9	.7	1.7	.6	.4	1.1	1.7
20	1.8	4.7	2.5	2.0	1.3	.7	.7	1.6	.6	.4	1.0	1.7
21	2.2	4.9	2.7	2.0	1.2	1.2	.8	1.5	.5	.5	.8	1.5
22	2.0	6.7	3.7	2.0	1.2	2.1	1.7	1.6	.5	.5	.8	1.5
23	2.2	5.2	4.3	2.4	1.1	1.5	1.2	1.5	.5	.6	1.0	1.5
24	4.7	4.8	3.7	2.0	1.1	1.4	1.0	1.5	.5	.1	1.5	1.4
25	4.8	4.5	3.4	2.0	1.0	1.0	1.1	1.4	.4	.1	1.8	1.2
26	3.0	4.0	3.3	2.0	1.0	1.0	1.1	1.3	.4	.2	1.4	1.2
27	2.5	3.4	3.6	3.5	.9	.9	1.0	1.8	.5	.1	1.2	1.4
28	2.4	3.4	3.1	3.0	1.0	.7	1.0	1.8	.6	.8	1.0	3.3
29	2.3	3.0	2.8	2.8	1.1	1.0	.9	1.8	.5	.6	1.0	3.8
30	2.3	.....	2.7	2.6	1.2	2.7	.8	1.6	.4	.5	1.3	2.8
31	2.1	.....	2.6	.....	2.8	.....	3.7	1.6	.....	.4	.....	2.2

NOTE.—The low water gage heights are liable to more or less error owing to the storing of water at developed powers above this station.

Rating table for Oconee River near Greensboro, Ga., from July 26, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.10	215	0.90	420	1.70	675	3.00	1,140
.20	235	1.00	450	1.80	710	3.20	1,220
.30	255	1.10	480	1.90	745	3.40	1,300
.40	280	1.20	510	2.00	780	3.60	1,384
.50	305	1.30	540	2.20	852	3.80	1,472
.60	330	1.40	570	2.40	924	4.00	1,560
.70	360	1.50	605	2.60	996		
.80	390	1.60	640	2.80	1,068		

It is based upon 18 discharge measurements made during 1903–4. It is well defined between gage heights 0.4 foot and 4 feet. Above 4 feet gage height, esti-

mates of daily discharge are based upon the extension of the rating curve, through two measurements at about 10 feet gage height.

Estimated monthly discharge of Oconee River near Greensboro, Ga., for 1903 and 1904.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
1903.			
July (26–31)	924	640	716
August	7,450	605	1,481
September	5,244	420	1,051
October	710	510	610
November	1,428	640	790
December	924	605	718
1904.			
January	1,924	640	868
February	4,070	780	1,576
March	3,676	960	1,464
April	1,472	780	941
May	1,780	420	656
June	1,180	380	578
July	1,428	360	508
August	6,522	540	1,348
September	1,472	280	481
October	390	215	278
November	710	330	468
December	1,876	510	812
The year	6,522	215	832

OCONEE RIVER AT MILLEDGEVILLE, GA.

This station was established August 22, 1903, by M. R. Hall, although several discharge measurements were made before that time. The first one was made by C. C. Babb on October 19, 1895. The bench mark to which the present gage is referred was used to get the water height at the time of each of these measurements.

The station is located at the iron highway bridge in the eastern part of Milledgeville, which consists of four spans, 100 feet, 150 feet, 150 feet, and 80 feet long, beginning at the right bank end, and short wooden trestles about 25 feet long at each end.

At low water the river is about 300 feet wide, including two piers, and often a sand bar of considerable extent in the third span. This bar sometimes practically stops the third-span channel, leaving the river about 200 feet wide. The bed is sandy and shifting, and the

water is shallow and swift. These conditions are unfavorable to accurate measurements as well as a constant rating. The channel is only slightly curved. Both banks are high and will not overflow. Measurements are made from the downstream side of the bridge, and the initial point is the end of the iron bridge at the right bank, downstream. The gage is read once daily by J. A. Brooks, who was paid by the Georgia Geological Survey until June 30, but has since that time been paid by the United States Weather Bureau.

Bench mark No. 1 is the top of the third floor beam from the pier on the east bank, downstream end. It is 39.00 feet above gage datum.

The gage established during August, 1904, is a boxed chain gage of the 24-inch box type, fastened to a horizontal timber, which is bolted at each end to the intermediate posts on the upstream side of the third panel of the third span from right bank. The bottom of the gage box is 43.80 feet above datum, and the length of chain is 45.80 feet. The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Oconee River at Milledgeville, Ga., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
August 22	M. R. Hall	299	1,022	2.24	3.95	2,301
September 11	do	282	604	1.89	2.39	1,141
September 12	do	270	570	1.83	2.27	1,042
October 16	F. A. Murray	264	607	1.87	2.39	1,140
December 16	do	293	821	2.31	3.05	1,908
December 18	do	292	738	2.33	2.74	1,720
1904.						
February 17	W. E. Hall	302	1,237	2.31	3.99	2,852
February 18	do	299	1,135	2.16	3.71	2,449
May 25	do	226	484	1.71	1.47	827
May 26	do	251	501	1.71	1.47	857
June 10	M. R. Hall	292	660	1.84	2.04	1,213
June 28	W. E. Hall	211	453	1.55	1.12	703
June 28	do	211	469	1.53	1.14	723
August 18	do	299	1,135	1.99	3.40	2,256
September 19	M. R. Hall	262	427	1.44	.95	628
October 11	W. E. Hall	197	304	1.10	.37	335
October 11	do	199	305	1.18	.41	361
October 12	do	209	341	1.20	.49	410

Mean daily gage height, in feet, of Oconee River at Milledgeville, Ga., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.90	3.40	3.90	3.20	2.50	3.55	2.40	4.60	1.80	0.60	0.60	1.30
2	2.85	3.40	3.90	3.50	2.40	3.65	2.35	2.90	1.40	.50	.60	1.40
3	2.80	3.20	3.80	3.20	2.35	2.65	2.10	2.80	1.40	.50	.70	2.30
4	2.80	3.20	3.80	3.10	2.40	2.20	1.80	3.60	1.30	.90	1.10	2.10
5	2.80	3.10	3.80	2.90	2.30	1.80	1.60	2.80	1.30	.60	1.70	2.50
6	2.75	3.10	3.40	3.00	2.10	1.55	1.50	2.40	2.70	.50	1.80	3.20
7	2.75	3.10	4.40	3.10	2.10	1.65	1.40	4.60	2.50	.50	1.50	4.80
8	2.75	5.20	6.40	3.40	2.10	2.25	1.20	[a]11.60	2.20	.50	1.50	4.10
9	2.75	5.20	7.40	3.70	2.10	2.75	1.20	7.20	1.80	.40	1.40	2.90
10	2.95	5.40	6.10	4.40	2.30	2.20	1.70	9.20	1.60	.80	1.30	2.50
11	2.95	9.50	4.70	3.60	3.50	1.70	2.20	11.60	1.30	.40	1.10	2.20
12	2.90	9.00	4.20	3.40	2.30	1.60	4.20	7.10	1.30	.50	1.30	2.10
13	3.00	6.70	3.90	3.00	2.20	2.10	2.10	5.20	1.30	.50	1.50	2.30
14	3.10	5.10	3.70	2.90	2.10	1.70	1.80	3.40	1.10	.50	1.80	2.10
15	3.10	4.60	3.90	2.75	2.10	1.50	1.40	2.80	1.20	.30	2.00	2.10
16	3.00	4.40	4.70	2.70	2.10	1.45	1.30	7.30	1.00	.20	1.80	2.40
17	3.00	4.00	4.00	2.70	2.10	1.45	1.10	5.50	1.20	.70	1.60	2.20
18	4.20	3.80	3.50	2.70	2.00	1.20	1.20	4.10	.90	.20	1.40	2.50
19	3.50	3.60	3.50	2.75	1.95	1.20	1.00	3.30	1.00	.20	1.30	2.30
20	3.40	3.60	3.40	2.70	1.80	1.10	1.20	2.70	.90	.30	1.20	2.10
21	3.10	3.70	3.30	2.70	1.75	1.00	.90	2.10	1.00	.30	1.10	2.00
22	3.20	6.90	3.30	2.65	1.75	1.40	1.00	1.90	1.00	.40	1.30	1.90
23	11.50	9.40	3.90	2.70	1.70	2.65	.60	1.80	.70	.40	1.40	1.80
24	8.95	8.10	6.10	2.75	1.65	2.00	1.50	1.60	.80	.40	1.50	1.70
25	5.70	6.30	6.20	2.60	1.60	1.65	1.80	2.10	.60	.30	1.70	1.70
26	4.50	5.10	4.60	2.50	1.45	1.40	2.40	1.90	.60	.30	1.90	1.80
27	3.80	4.40	4.10	2.75	1.25	1.40	1.80	2.10	.60	.30	1.60	1.80
28	3.60	4.10	4.30	2.85	1.45	1.10	1.40	2.60	.50	.60	1.30	5.40
29	3.60	4.10	3.80	2.75	1.45	2.00	1.40	2.10	.50	.80	1.20	4.80
30	3.60	.....	3.40	2.60	1.60	1.80	1.40	2.00	.40	.70	1.40	5.30
31	3.40	.....	3.30	.....	2.55	.....	2.40	1.80	.....	.70	.....	3.00

[a] This height is doubtful.

NOTE.—Owing to the irregular running of the mill above this station during the low-water period, the true mean gage height was not always obtained, although two readings were made each day. From this cause the gage heights below 0.5 foot are probably too low and in some cases gage heights above 0.5 foot may be artificially high.

Rating table for Oconee River at Milledgeville, Ga., from August 25, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.20	290	1.00	630	1.70	1,010	2.80	1,760
.30	330	1.10	680	1.80	1,070	3.00	1,920
.40	370	1.20	730	1.90	1,130	3.20	2,090
.50	410	1.30	785	2.00	1,190	3.40	2,265
.60	450	1.40	840	2.20	1,320	3.60	2,450
.70	495	1.50	895	2.40	1,460	3.80	2,640
.80	540	1.60	950	2.60	1,610	4.00	2,840
.90	585						

The foregoing table is based upon twelve discharge measurements made during 1904. It is well defined between gage heights 0.2 foot and 4 feet. Above 4-feet gage height, daily discharge estimates are based on a tangent, the difference being 105 per tenth.

Estimated monthly discharge of Oconee River at Milledgeville, Ga., for 1903 and 1904.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
1903.			
August 25–31	2,090	1,573	1,823
September	16,800	1,255	2,998
October	4,625	1,320	1,702
November	2,740	1,573	1,872
December	2,740	1,648	1,911
1904.			
January	10,720	1,723	2,643
February	8,615	2,005	3,903
March	6,410	2,175	3,152
April	3,260	1,535	1,926
May	2,355	758	1,229
June	2,498	630	1,138
July	3,050	450	1,019
August	10,820	950	3,138
September	1,685	370	755
October	585	[a] 290	403
November	1,190	450	840
December	4,310	785	1,638
The year	10,820	290	1,815

[a] See note under gage heights.

OCONEE RIVER AT DUBLIN, GA.

Oconee River rises in the northern part of Georgia, near Gainesville, on the southern slope of the Chattahoochee Ridge, which separates the headwaters of this stream from the tributaries of Chattahoochee River. It flows in a southeasterly direction and joins the Ocmulgee at the southern border of Montgomery County to form the Altamaha. The drainage area is for the most part hilly and is made up of cultivated ground broken by extensive tracts of forest.

A station was established by the United States Weather Bureau in 1894 at Dublin, Ga., about 60 miles above the junction of the Oconee with the Ocmulgee. Records were kept, with the exception of the summer months of 1896, until April 30, 1897, when the station was discontinued. In 1898 discharge measurements were commenced by

the United States Geological Survey, and on February 11 an observer was employed to read the gage. On October 15, 1898, the Weather Bureau again adopted the station and has maintained the gage and furnished gage heights to the Geological Survey continuously since that time. The present observer is R. F. Mathis, who reads the gage once daily.

The gage is a heavy timber bolted to the downstream side of the center pier of the Wrightsville and Tennille Railroad bridge in the eastern part of the city of Dublin. The bridge is a drawbridge, and the pier to which the gage is attached is the circular center pier of the turn span. The gage is graduated to feet and tenths, and the markings face toward the right bank. A secondary sloping gage is attached to a solid rock on right bank about 25 feet above the railroad bridge. This gage is graduated by chisel cuts on a 3-inch by 5-inch oak timber, and reads from −1.6 to +1.9. Measurements are made from the iron highway bridge, which is 500 feet upstream from the gage. This bridge is also a drawbridge, and consists of the turn span between two other spans of 75 feet each. The total length of bridge proper is 320 feet. On the left bank, which is low, there is 1,100 feet of iron-frame trestle approach. There is also a short trestle on the right bank, which is high. The ordinary width of the river is about 235 feet. At a gage height of about 20 feet the left bank begins to overflow, and it is practically covered to end of the approach at 25 feet. This ground is thickly covered with a brushy growth, which will no doubt cause the velocity of the water overflowing it to be small. The right bank does not overflow. The bed of the stream is of loose rock, sand, and gravel. The channel is straight and the current is swift and fairly uniform, except where it is broken by the three bridge piers. The initial point for soundings is the end of the bridge at the right bank, on the upstream side.

Bench mark No. 1 is the top of the upstream end of the floor beam on top of the first tubular pier and is 41.30 feet above the zero of the gage. Bench mark No. 2 is a point on the fifth step from the bottom at the south entrance of the court-house, 6 inches from the east end of the step. Its elevation is 82.51 feet above the zero of the gage. Bench mark No. 3 is the top of the granite water table 2½ feet west of the southeast corner of the court-house. Its elevation is 80.97 feet above the zero of the gage. Bench mark No. 4 consists of three large nails driven into a cypress tree on the right bank about 200 feet above the bridge. Its elevation is 3.00 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Oconee River at Dublin, Ga., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
April 3	J. M. Giles		5,038	4.00	15.40	20,160
April 4	do		4,930	4.02	14.95	19,800
June 6	F. A. Murray		2,923	3.35	8.81	9,804
June 6	do		2,832	3.33	8.51	9,432
June 15	do		1,824	2.75	4.47	5,017
July 15	do		2,235	2.93	5.95	6,579
August 24	do		1,910	2.34	4.61	4,475
October 6	do		806	2.12	.12	1,713
November 14	M. R. Hall		1,114	2.22	1.15	2,472
1904.						
February 18	F. A. Murray	248	1,998	2.57	4.33	5,136
April 12	W. E. Hall	242	1,528	2.30	2.45	3,521
July 21	M. R. Hall	210	729	1.11	— .98	808
September 16	W. E. Hall	200	750	1.12	— .90	840
September 17	do	200	732	1.09	— .95	798
October 27	B. S. Drane	249	662	.78	—1.55	515
October 27	do	249	666	.84	—1.55	557
December 3	W. E. Hall	222	1,086	1.81	.45	1,968

Mean daily gage height, in feet, of Oconee River at Dublin, Ga., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.7	2.5	3.9	2.5	1.0	0.0	−0.1	−0.5	0.6	−1.3	−1.1	0
2	1.7	2.8	3.5	2.0	1.0	.8	.2	.8	.1	−1.4	−1.2	−
3	1.7	2.7	3.5	2.0	1.0	2.0	.6	1.4	− .3	−1.3	−1.1	
4	1.6	2.7	3.9	2.0	.7	1.3	.2	.9	− .4	−1.3	-1.0	1.
5	1.6	2.7	4.0	1.8	.7	.5	− .4	1.5	− .5	−1.3	− .8	1.
6	1.6	2.0	3.9	1.6	.7	.3	− .6	2.4	− .5	-1.3	− .5	1.
7	1.5	2.0	3.9	1.6	.4	.1	− .7	1.6	.4	−1.3	− .3	1.
8	1.4	3.0	4.5	2.0	.4	.1	− .7	2.4	1.1	−1.4	− .3	2.
9	1.4	5.0	5.5	2.0	.3	.0	− .8	5.0	.6	- 1.3	− .4	2.
10	1.6	7.0	5.5	2.7	.3	− .1	− .8	6.2	.2	−1.3	− .7	2.
11	1.4	8.5	6.8	3.0	.3	− .3	- .9	6.5	-- .1	−1.4	− .7	1.
12	1.4	9.0	5.5	3.0	.3	− .5	− .7	6.8	− .4	−1.3	− .5	
13	2.0	9.9	4.0	2.0	1.0	− .1	.2	6.9	− .7	−1.4	.5	
14	2.0	9.9	3.5	2.0	1.0	− .1	.3	6.6	− .7	−1.4	− .3	
15	2.0	9.9	3.4	1.4	1.0	− .1	− .4	3.5	− .7	--1.4	- .1	
16	2.0	7.5	3.4	1.0	.7	− .3	− .6	1.8	− .8	−1.4	- .2	
17	2.0	5.5	3.4	1.0	.7	− .5	− .8	3.8	− .9	−1.4	− .1	
18	2.0	4.5	3.4	1.0	.7	− .5	− .9	3.3	- .9	−1.5	− .1	
19	3.0	4.0	3.0	1.0	.7	− .5	−1.0	3.0	− .9	--1.4	− .2	
20	2.8	3.5	2.9	1.0	.7	− .6	−1.0	2.0	−1.0	−1.5	− .4	
21	2.6	4.0	2.5	1.0	.7	− .5	−1.0	.9	−1.0	- 1.5	- .4	
22	2.0	5.5	2.0	1.0	.4	− .5	−1.0	.4	−1.0	−1.5	− .5	
23	2.9	7.0	2.0	1.0	.4	− .5	− .8	.1	−1.0	−1.5	− .5	
24	6.6	7.8	2.9	1.0	.4	− .1	- .8	− .1	−1.1	--1.5	− .4	
25	7.6	8.0	3.8	1.0	.0	− .1	− .6	.1	−1.1	−1.5	− .3	
26	7.8	8.3	5.0	1.0	.0	.4	.3	.3	- 1.1	−1.5	- .1	
27	6.9	7.0	4.5	1.0	.0	− .8	− .2	.9	−1.2	−1.4	- .1	
28	4.4	5.0	4.0	1.0	− .2	− .9	− .1	2.5	−1.2	−1.4	- .1	
29	3.6	4.0	3.8	1.0	− .2	− .8	− .4	3.0	−1.2	−1.4	.2	
30	3.2	.....	3.4	1.0	− .5	− .5	− .6	1.0	−1.2	−1.3	- .4	
31	2.9	.....	3.0	.....	.0	.....	− .6	1.0	.....	--1.1	.....	

Rating table for Oconee River at Dublin, Ga., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet*
−1.50	560	−0.30	1,305	1.60	2,800	5.00	5,790
−1.40	600	− .20	1,381	1.80	2,964	5.50	6,300
−1.30	645	− .10	1,457	2.00	3,130	6.00	6,830
−1.20	695	.00	1,534	2.20	3,296	6.50	7,380
−1.10	750	.20	1,688	2.40	3,462	7.00	7,930
−1.00	810	.40	1,842	2.60	3,630	7.50	8,505
− .90	874	.60	1,998	2.80	3,799	8.00	9,090
− .80	941	.80	2,154	3.00	3,969	8.50	9,690
− .70	1,010	1.00	2,312	3.50	4,402	9.00	10,330
− .60	1,081	1.20	2,473	4.00	4,850	9.50	10,980
− .50	1,154	1.40	2,636	4.50	5,310	10.00	11,630
− .40	1,229						

The foregoing table is based upon eight discharge measurements made during 1904. It is fairly well defined between gage heights −1.50 feet and 4.30 feet. Above 4.30 the curve is rather uncertain. The table has been extended beyond these limits.

Estimated monthly discharge of Oconee River at Dublin, Ga., for 1904.

[Drainage area, 4,182 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	8,850	2,636	3,897	0.932	1.07
February	11,500	3,130	6,599	1.58	1.70
March	7,710	3,130	4,717	1.13	1.30
April	3,969	2,312	2,766	.661	.738
May	2,312	1,154	1,899	.454	.523
June	3,130	874	1,449	.346	.386
July	1,998	810	1,169	.280	.323
August	7,820	1,154	3,617	.865	.997
September	2,392	695	1,131	.270	.301
October	750	560	609	.146	.168
November	1,611	695	1,205	.288	.321
December	3,969	1,154	2,329	.557	.642
The year	11,500	560	2,616	.626	8.47

OHOOPEE RIVER NEAR REIDSVILLE, GA.

This station was established June 13, 1903, by F. A. Murray. It is located at the wooden highway bridge, commonly known as Sheppards Bridge, 4½ miles west of Reidsville. The gage is on the downstream side of the middle post which supports the bridge protector. The section from zero to 10 feet is two 5-foot sections of notched and painted gage fastened with lag screws to the post. From 10 to 13 feet the post is graduated to feet and half feet with white paint, and from 13 to 20 feet it is graduated to feet with nails and numbered with brass figures. On November 19, 1903, a new 1 by 4 inch section 5 feet long, reading from 3 to 8 feet, was spiked to a pine plank which is securely nailed to a cypress tree on the left bank of the river about 120 feet above the bridge. The observer is J. D. Swain, who is paid by the Georgia Geological Survey. Bench mark No. 1 is the top of the cap of the fifth bent from the left end of the bridge on the upstream side, opposite a point 106 feet from the initial point for soundings. It is at an elevation of 20.00 feet above the zero of the gage. Bench mark No. 2 consists of two nails driven horizontally in the downstream side of a cypress tree on the left bank about 120 feet

above the bridge. This bench mark is 8.00 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Ohoopee River near Reidsville, Ga., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet*
June 13	F. A. Murray		2,001	2.88	12.47	5,762
June 24	do		1,187	1.40	6.41	1,692
July 16	do		1,650	2.20	10.34	3,667
July 16	do		1,774	2.10	10.46	3,756
August 22	do		2,183	2.95	14.00	6,441
October 8	do		667	.71	2.84	476
October 8	do		635	.72	2.85	462
November 19	do		889	1.27	4.96	1,131
December 30	do		1,123	1.63	6.69	1,836
1904.						
February 19	F. A. Murray	136	1,667	2.16	10.19	3,611
April 13	W. E. Hall	115	775	1.34	4.53	1,038
July 23	M. R. Hall	112	490	.76	2.28	369
September 13	W. E. Hall	113	713	1.15	4.20	823
September 13	do	113	708	1.21	4.20	858
September 14	do	113	641	.98	3.63	628
September 15	do	113	578	.81	3.00	470
September 15	do	113	569	.80	3.00	454
October 31[a]	B. S. Drane		42	1.25	.32	52
December 1	W. E. Hall	108	423	.45	1.56	190

[a] Wading 1,000 feet above the bridge. Three narrow channels.

Mean daily gage height, in feet, of Ohoopee River near Reidsville, Ga., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	6.4	6.7	8.2	4.4	1.4	0.9	0.5	1.1	8.3	1.1	0.3	1.6
2	6.6	6.4	7.8	4.8	1.4	1.6	.5	1.0	6.4	1.0	.3	1.4
3	.....	6.0	7.8	4.1	1.3	1.8	.5	2.2	6.5	1.0	.7	1.6
4	6.1	5.6	7.0	3.8	1.3	1.5	.6	4.6	6.0	.9	1.0	1.8
5	6.0	5.3	7.1	3.5	1.3	1.2	1.0	6.2	5.2	.8	1.5	2.1
6	5.4	5.0	7.1	3.3	1.1	1.1	1.2	8.4	4.3	.8	1.5	2.8
7	4.8	4.8	7.1	3.0	1.1	1.0	1.1	9.0	4.8	.7	1.5	3.1
8	4.6	5.0	7.4	2.9	1.0	.9	1.0	9.8	5.6	.6	1.3	3.1
9	4.8	5.1	7.8	2.8	1.0	.7	.8	9.0	5.6	.7	1.0	3.0
10	.....	6.0	8.0	3.8	1.0	.7	1.1	8.4	5.5	.7	.9	2.8
11	.....	8.2	8.0	4.6	.9	.6	1.4	8.6	5.1	.7	.8	2.7
12	.....	12.1	7.8	4.8	.9	.6	1.0	9.0	5.0	.7	.7	2.5
13	.....	12.0	7.6	4.7	.8	.6	1.0	9.4	4.4	.6	1.0	2.5
14	.....	.....	7.5	4.4	.8	.5	.8	8.9	3.6	.6	1.5	2.4
15	.....	11.5	7.1	3.4	.7	.5	.6	8.6	3.1	.7	1.9	2.3
16	.....	11.2	6.9	3.1	.7	.5	.8	8.3	2.6	.6	2.0	2.2
17	2.6	11.0	6.6	2.8	.7	.5	.6	7.6	2.3	.6	1.8	2.2
18	2.4	10.7	6.2	2.3	.7	.4	.5	6.3	2.1	.5	1.5	2.2
19	2.4	10.1	5.9	2.1	.6	.4	.5	6.4	1.9	.5	1.3	2.1
20	2.3	9.4	5.7	2.0	.6	.5	.4	5.4	1.6	.4	1.2	2.1
21	2.3	9.3	5.3	1.9	.6	.4	.4	4.8	1.5	.4	1.1	2.0
22	2.9	9.8	5.1	1.8	.6	.9	.6	4.5	1.5	.4	1.0	2.0
23	3.1	10.1	4.9	1.8	.5	.8	2.3	3.9	2.1	.4	1.1	1.9
24	4.0	10.4	4.6	1.7	.5	.6	1.9	3.7	2.2	.4	1.6	1.9
25	4.8	10.2	4.7	1.6	.5	.6	1.7	3.9	1.9	.3	1.2	1.9
26	5.7	9.8	4.8	1.5	.5	.5	1.5	3.9	1.7	.3	2.7	1.8
27	6.4	9.3	4.6	1.4	.5	.5	1.5	3.9	1.5	.4	2.4	1.9
28	7.2	.....	4.8	1.4	.5	.5	1.4	5.4	1.3	.4	2.2	2.0
29	7.8	8.5	4.9	1.5	.9	.5	1.5	6.3	1.2	.3	1.8	2.4
30	7.1	.....	5.0	1.5	1.1	.5	1.5	9.2	1.2	.3	1.6	2.7
31	6.8	.....	4.6	.....	.8	.....	1.3	9.2	.....	.3	.....	2.7

Rating table for Ohoopee River near Reidsville, Ga., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.30	50	1.60	197	3.80	690	7.00	1,950
.40	57	1.70	213	4.00	755	7.50	2,184
.50	65	1.80	230	4.20	824	8.00	2,430
.60	74	1.90	247	4.40	895	8.50	2,685
.70	83	2.00	265	4.60	968	9.00	2,950
.80	93	2.20	302	4.80	1,043	9.50	3,222
.90	104	2.40	341	5.00	1,120	10.00	3,500
1.00	115	2.60	382	5.20	1,198	10.50	3,800
1.10	127	2.80	425	5.40	1,277	11.00	4,120
1.20	140	3.00	470	5.60	1,357	11.50	4,460
1.30	153	3.20	519	5.80	1,438	12.00	4,820
1.40	167	3.40	572	6.00	1,520	12.50	5,198
1.50	182	3.60	629	6.50	1,728	13.00	5,590

The foregoing table is based upon nineteen discharge measurements made during 1903 and 1904. It is well defined between gage heights 0.0 foot and 11.0 feet. Above gage height 11.0 the table is determined by one measurement at 14.0 feet.

Estimated monthly discharge of Ohoopee River near Reidsville, Ga., for 1904.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
January	2,330	321	1,062
February	4,894	1,043	2,877
March	2,531	968	1,703
April	1,043	167	495
May	167	65	101
June	230	57	91.8
July	321	57	125
August	3,388	115	1,811
September	2,582	140	747
October	127	50	74.0
November	403	50	170
December	494	167	316
The year	4,894	50	798

MISCELLANEOUS MEASUREMENTS IN ALTAMAHA RIVER DRAINAGE BASIN.

The following is a list of miscellaneous discharge measurements made in Altamaha River drainage basin during 1904:

Yellow River near Jackson, Ga.—A measurement was made October 7 at the wagon bridge, 11 miles from Jackson, on the road to Covington, Ga. The bench mark is the downstream edge of the bridge floor, 40 feet from the initial point for soundings, and is 8.00 feet above the datum of the gage.

Width, 113 feet; area, 229 square feet; mean velocity, 0.30 foot per second; gage height, 1.80 feet; discharge, 69 second-feet.

South River near Jackson, Ga.—A measurement was made October 7 at the wagon bridge, 10 miles from Jackson, on the road to Covington, Ga. The bench mark is the upstream end of floorbeam, 66 feet from the initial point for soundings, 20.00 feet above the datum of the gage.

Width, 121 feet; area, 152 square feet; mean velocity, 0.90 foot per second; gage height, 1.10 feet; discharge, 137 second-feet.

Pole Bridge Creek near Lithonia, Ga.—This stream is a tributary of South River from the left near Lithonia, Ga. A measurement was made July 16 near the mouth of the creek, on the road between New's Bridge and Parker Bridge.

Width, 15 feet; area, 7 square feet; mean velocity, 1.43 feet per second; discharge, 10 second-feet.

A measurement at the same section September 23 gave the following results:

Width, 17 feet; area, 7 square feet; mean velocity, 1.00 foot per second; discharge, 7 second-feet.

Alcovy River near Newton Factory, Ga.—A measurement was made October 7 from the wagon bridge at Henderson's mill, 4 miles from Newton Factory, on the road to Covington, Ga. The bench mark is the upstream edge of the bridge floor, 90 feet from the initial point for soundings, 11.00 feet above the datum of the gage.

Width, 40 feet; area, 43 square feet; mean velocity, 1.46 feet per second; gage height, 1.25 feet; discharge, 62 second-feet.

Horse Creek near Lumber City, Ga.—This stream is a tributary of Ocmulgee River from the left. A measurement was made September 8, 1½ miles above the mouth of the creek, 10 miles north of Lumber City. The bench mark is a nail driven into the end of the second floorbeam above the second bent from the left bank, 15.00 feet above the zero of the gage.

Width, 55 feet; area, 115 square feet; mean velocity, 1.03 feet per second; gage height, 3.17 feet; discharge, 118 second-feet.

Little Ocmulgee River at Wilcox, Ga.—A measurement was made September 7 at the wagon bridge at Wilcox, 2½ miles upstream from Lumber City, Ga. The bench mark is the center of lag bolt driven into the end of the second floorbeam from the right bank on the downstream side, 15.00 feet above the zero of the gage.

Width, 100 feet; area, 488 square feet; mean velocity, 1.92 feet per second; gage height, 3.15 feet; discharge, 937 second-feet.

Sugar Creek at Wilcox, Ga.—A measurement was made September 7, from the Southern Railway bridge, one-fourth mile north of Wilcox. The bench mark is the top of the steel girder, upstream side, 150 feet from the right end of the trestle, 25.00 feet above the datum of the gage.

Width, 41 feet; area, 117 square feet; mean velocity, 1.06 feet per second; gage height, 7.50 feet; discharge, 124 second-feet.

Oconee River near Milledgeville, Ga.—Measurements were made at Fraley's ferry, 6 miles upstream from Milledgeville. The bench mark is a nail in an ash tree on the right bank, 100 feet above the ferry, 10.00 feet above the datum of the gage.

June 29; width, 270 feet; area, 1,310 square feet; mean velocity, 0.79 foot per second; gage height, 4.90 feet; discharge, 1,030 second-feet.

September 20; width, 207 feet; area, 1,108 square feet; mean velocity, 0.50 foot per second; gage height, 4.35 feet; discharge, 547 second-feet.

Beaverdam Creek near Greensboro, Ga.—This stream enters Oconee River from the left. A measurement was made March 19, at Veazey Ford, 6 miles south of Greensboro, on the road to Sparta, Ga. The

bench mark is a nail in a small ash tree on the left bank, 20 feet below the foot plank, 3.00 feet above the datum of the gage.

Width, 15 feet; area, 10 square feet; mean velocity, 1.70 feet per second; gage height, 1.50 feet; discharge, 17 feet.

Little River near Milledgeville, Ga.—A measurement was made from the wagon bridge, 9 miles north of Milledgeville, 1 mile above the mouth of the river. The bench mark is the top of the downstream end of the cap of left bent of the second pier from the left bank, marked by a copper brad. Its elevation is 15.00 feet above the datum of the gage.

Width, 89 feet; area, 65 square feet; mean velocity, 1.09 feet per second; gage height, 3.17 feet; discharge, 71 second-feet.

MINOR SOUTHERN ATLANTIC DRAINAGE BASINS.

MISCELLANEOUS MEASUREMENTS.

The following miscellaneous discharge measurements were made in the Satilla River drainage basin during 1904:

Satilla River near Waycross, Ga.—A measurement was made September 9, at the covered wagon bridge, 3 miles east of Waycross. The bench mark is the center of lag bolt driven into the left side of the first floorbeam from the first pier from the left bank, 20.00 feet above the datum of the gage.

Width, 108 feet; area, 1,077 square feet; mean velocity, 1.07 feet per second; gage height, 8.2 feet; discharge, 1,150 second-feet.

Hurricane Creek near Blackshear, Ga.—This stream is an important tributary of Satilla River, entering from the north. A measurement was made September 10, at Baxley's bridge, near Blackshear. The bench mark is a large nail driven into the downstream end of the floorbeam over the second pier from the right bank, 15.00 feet above the datum of the gage.

Width, 67 feet; area, 415 square feet; mean velocity, 1.35 feet per second; gage height, 6.57 feet; discharge, 562 second-feet.

APALACHICOLA RIVER DRAINAGE BASIN.

Apalachicola River is formed by the union of Flint and Chattahoochee rivers at the Georgia-Florida line. It flows in a southerly direction through Florida to the Gulf of Mexico. It is navigable, and boats run up Flint River to Albany, Ga., and up Chattahoochee River to Columbus, Ga.

Flint River rises in Fulton County, Ga., a few miles south of Atlanta. It flows in a southerly direction to Talbot County, southeasterly to Macon County, southerly to Worth County, and southwesterly to Apalachicola River. It drains the south-central portion of Georgia, extending from Atlanta south to the Florida line. The

tributaries to Flint River are mainly large creeks with much fall. The principal ones among these are Whitewater, Whiteoak, Redoak, Elkins, Big Potato, Muckalee, Kinchafoonee, Ichawaynochaway, and Spring creeks.

Flint River has many good water powers on its course. Between a point opposite Woodbury, Ga., and a point opposite Knoxville, Ga., in Crawford County, a distance of about 45 miles, the river falls 334 feet. Very little of its power is yet developed.

Chattahoochee River rises in the Blue Ridge, in White County, and flows in a southwesterly direction until it reaches the Alabama line at the southwest corner of Troup County, Ga. From there it flows in a southerly direction, forming the western boundary of Georgia, until it flows into Apalachicola River at the southern boundary of the State. It drains almost all of the north-central, middle-west, and southwest portions of Georgia, and has a drainage area of 4,900 square miles at Columbus, Ga., which is at the fall line.

Soque River joins the Chattahoochee on the western edge of Habersham County. This river rises in Habersham County and flows in a southwesterly direction. It has considerable fall, dropping as much as 40 feet within a few hundred feet.

Farther down the Chattahoochee, at the west boundary of Hall County, Chestatee River enters. It rises in Lumpkin County and flows in a southerly direction through a very hilly and steep country and has much fall all along its course.

From its source down to Columbus, Ga., Chattahoochee River is an excellent water-power stream. From the lower edge of Lumpkin County down to Columbus, Ga., there is a fall of over 850 feet, 366 feet of this fall being between Westpoint and Columbus. All along its course there are many small tributaries flowing from a high, hilly country. These have much fall, and many small water powers are available.

The following pages give the results of the data collected at this station during 1904:

CHATTAHOOCHEE RIVER NEAR CORNELIA, GA.

This station was established as a bench-mark station. It is located at Duncan Bridge, about 7 miles northwest of Cornelia, Ga., and 1 mile below the mouth of Soque River. Discharge measurements are made from the downstream side of the inclosed wooden highway bridge, the meter being lowered through holes cut in the floor or by raising floor plank. The initial point for soundings is the end of the bridge at the left bank, downstream side. The channel is curved for about 500 feet above and straight for about 800 feet below the station. The current is moderate. The right bank is clean, and overflows for about 200 feet. The left bank is high, rocky, wooded, and does not overflow. The

bed of the stream is composed of rock at the left and silt at the right bank, free from vegetation, and shifting. There is but one channel at all stages, broken by the piers of the bridge. A fish-trap dam about 800 feet below the bridge will probably affect the rating at this station. The bench mark is the top of downstream stringer at a point 50 feet from the left end of the bridge. Its elevation is 21.00 feet above datum.

Discharge measurements of Chattahoochee River near Cornelia, Ga., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
June 8.....	J. M. Giles	124	363	1.34	1.40	487
September 30 ..	A. T. Mitchelson	115	364	.70	.95	256
October 29.....	M. R. Hall	103	319	.67	.91	215

CHATTAHOOCHEE RIVER NEAR NORCROSS, GA.

This station was established June 10, 1902, by M. R. Hall. It is located at Medlock's toll bridge, about 4½ miles north of Norcross, Ga. This point is above the mouth of Johns Creek and below the mouth of Sewannee Creek. A vertical section of gage, reading from zero to 8 feet, is attached to an oak tree on the right bank of the river, 100 feet above the bridge. A chain gage was established March 14, 1903. The center of the pulley is 28.32 feet above the zero of the gage, and the length of the chain from the end of the weight to the marker is 28.75 feet. The gage is read twice each day by W. O. Medlock, the bridge owner. He is paid by the Georgia Geological Survey. Discharge measurements are made from the downstream side of the single-span bridge and its approaches. The initial point for soundings is 50 feet to right of the center of the downstream tubular pier on the right bank. The channel is slightly curved for 600 feet above and 700 feet below this station. The current is sluggish at low stages, but not excessively so, and the discharge measurements are considered good at lowest stage. The right bank is high and will overflow only for 50 feet from the water's edge; the left bank will overflow for about 800 feet at a gage height of from 16 to 18 feet. The bed of the stream is sandy and probably changes.

Bench mark No. 1 is the top of the iron pier on the right bank, downstream side. Its elevation is 27.00 feet above gage datum. Bench mark No. 2 is a copper plug set in a stone post set flush with the surface of the ground at the side of the road just outside of the toll bridge, on the right bank. The post is on line with the downstream side of the bridge and is 145 feet from the center of the pier at the right-bank end of the bridge. Its elevation is 26.92 feet above gage datum.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Chattahoochee River near Norcross, Ga., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
January 9	M. R. Hall		1,375	1.34	2.70	1,837
March 14	do		2,035	2.43	5.35	4,940
May 5	do		1,854	1.91	4.08	3,543
May 29	J. M. Giles		1,583	1.50	3.15	2,378
June 26	do		1,570	1.56	3.13	2,447
July 17	M. R. Hall		1,537	1.46	3.06	2,254
July 17	do		1,537	1.46	3.06	2,255
August 19	do		1,503	1.55	3.15	2,337
August 19	do		1,486	1.54	3.05	2,288
August 19	F. A. Murray		1,503	1.52	3.15	2,281
August 19	do		1,486	1.48	3.05	2,203
September 26	do		1,245	.96	2.06	1,197
October 23	do		1,265	.85	1.94	1,078
November 25[a]	do		493	2.15	1.95	1,062
November 25	do		1,221	.87	1.95	1,071
1904.						
January 19	W. E. Hall	174	1,308	1.08	2.19	1,419
January 19	C. A. Greene	174	1,308	1.04	2.19	1,362
February 20	M. R. Hall and J. C. Hoyt.	169	1,467	1.78	3.45	2,607
April 7	W. E. Hall	173	1,314	1.14	2.50	1,496
June 7	J. M. Giles	160	1,234	1.27	2.54	1,571
June 20	M. R. Hall	155	1,049	.63	1.53	662
August 9	W. E. Hall	190	2,354	4.22	8.62	9,938
August 9	do	180	1,972	3.36	6.57	6,624
August 10	do	177	1,410	1.88	3.60	2,658
September 28	M. R. Hall	156	917	.59	1.22	537
September 28	do	156	919	.59	1.22	538
October 11	B. S. Drane	166	943	.60	1.32	569
October 14	M. R. Hall and N. C. Grover.	158	925	.60	1.28	558
December 9	M. R. Hall	163	1,002	.95	1.88	951

[a] Measurement taken at Warsaw Ferry, 1 mile above bridge.

Mean daily gage height, in feet, of Chattahoochee River near Norcross, Ga., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec
1	1.90	2.20	2.50	2.55	2.30	2.40	1.70	2.65	1.80	1.35	1.25	[illegible]
2	1.90	2.10	2.60	2.55	2.25	2.30	1.55	2.70	1.75	1.30	1.30	[illegible]
3	2.00	2.10	2.60	2.50	2.20	2.30	1.50	2.35	1.70	1.35	1.35	[illegible]
4	1.90	2.10	2.40	2.40	2.50	2.10	1.45	2.20	1.90	1.20	1.50	[illegible]
5	1.90	2.10	2.30	2.35	2.40	1.95	1.70	3.10	2.40	1.15	1.65	[illegible]
6	1.80	2.10	2.30	2.35	2.30	1.90	1.55	2.55	2.10	1.25	1.60	[illegible]
7	1.80	2.30	4.70	2.50	2.20	2.65	1.50	2.15	2.05	1.30	1.50	[illegible]
8	2.00	3.00	6.00	3.20	3.60	2.30	1.50	7.70	1.80	1.30	1.45	2.1
9	1.90	2.90	3.90	3.40	4.05	2.05	1.30	8.20	1.70	1.30	1.40	1.9
10	1.90	2.70	3.30	3.70	3.60	1.90	1.30	3.70	1.80	1.15	1.40	[illegible]
11	1.90	2.70	3.00	3.00	2.80	1.80	1.55	4.50	1.65	1.25	1.40	[illegible]
12	2.00	2.70	2.85	2.80	2.55	1.90	1.75	3.95	1.55	1.10	1.40	[illegible]
13	2.00	2.50	2.70	2.70	2.40	1.80	1.85	2.85	1.60	1.30	1.60	[illegible]
14	2.10	2.30	3.20	2.60	2.35	1.80	1.90	2.55	1.55	1.30	1.65	[illegible]
15	2.10	2.30	3.10	2.50	2.35	1.70	1.60	2.40	1.50	1.20	1.60	[illegible]
16	2.00	2.30	2.75	2.50	2.25	1.70	1.60	2.50	1.45	1.25	1.50	[illegible]
17	2.20	2.20	2.60	2.55	2.20	1.70	1.85	2.15	1.45	1.25	1.50	[illegible]
18	2.50	2.10	2.55	2.50	2.20	1.65	1.50	2.00	1.45	1.15	1.45	[illegible]
19	2.20	2.30	2.50	2.45	2.15	1.20	1.65	1.90	1.40	1.10	1.45	[illegible]
20	2.10	3.50	2.45	2.40	2.15	1.60	1.40	2.00	1.40	1.10	1.45	[illegible]
21	2.00	3.60	2.60	2.40	2.10	1.50	1.70	2.20	1.40	1.10	1.40	[illegible]
22	2.80	4.90	3.00	2.40	2.10	1.45	1.85	1.85	1.40	1.25	1.55	[illegible]
23	3.10	5.30	3.40	2.40	2.05	1.35	2.05	1.70	1.40	1.25	1.80	[illegible]
24	3.30	4.00	3.60	2.35	2.00	1.25	1.70	1.80	1.45	1.20	1.85	[illegible]
25	2.60	3.30	3.50	2.30	2.00	1.20	1.60	2.05	1.40	1.20	1.65	[illegible]
26	2.40	2.90	3.20	2.30	2.00	1.20	1.80	2.00	1.30	1.25	1.55	[illegible]
27	2.30	2.80	3.00	2.45	1.95	1.40	1.80	2.40	1.20	1.30	1.50	[illegible]
28	2.20	2.60	2.90	2.50	1.90	1.95	1.60	2.80	1.20	1.20	1.45	[illegible]
29	2.20	2.60	2.75	2.35	1.90	2.30	1.70	2.45	1.25	1.10	1.45	[illegible]
30	2.20	.....	2.65	2.30	2.00	2.40	2.10	2.05	1.40	1.30	1.50	[illegible]
31	2.20	.....	2.60	.....	2.50	.....	1.90	1.90	.....	1.30	.....	[illegible]

Rating table for Chattahoochee River near Norcross, Ga., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.10	480	1.90	1,015	3.20	2,410	5.50	5,210
1.20	515	2.00	1,120	3.40	2,630	6.00	5,885
1.30	560	2.20	1,330	3.60	2,860	6.50	6,580
1.40	615	2.40	1,540	3.80	3,090	7.00	7,295
1.50	680	2.60	1,750	4.00	3,320	7.50	8,035
1.60	750	2.80	1,970	4.50	3,920	8.00	8,805
1.70	830	3.00	2,190	5.00	4,555	8.20	9,125
1.80	920						

The above table is based upon discharge measurements made during 1902, 1903, and 1904, and is well defined. Above gage height 1.90 feet it is the same as the 1903 curve.

Estimated monthly discharge of Chattahoochee River near Norcross, Ga., for 1904.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
January	2,520	920	1,306
February	4,945	1,225	1,967
March	5,885	1,435	2,227
April	2,975	1,435	1,729
May	3,380	1,015	1,510
June	1,805	515	987
July	1,225	560	814
August	9,125	830	2,079
September	1,540	515	764
October	588	480	530
November	968	537	689
December	3,090	588	1,119
The year	9,125	480	1,310

CHATTAHOOCHEE RIVER AT OAKDALE, GA.

This station was established at Oakdale, Ga., on October 17, 1895, by Cyrus C. Babb. It is located at the Southern Railway bridge, 1 mile above the mouth of Proctor Creek, 2 miles below the mouth of Peachtree Creek, one-fourth mile west of Chattahoochee, 1 mile east of Oakdale, and 8 miles northwest of Atlanta.

On July 30, 1896, the location of the station was changed to Mason and Turner's ferry, 1 mile below Oakdale. The gage at this point, know as the "Oakdale lower gage," is nailed to a tree on the right bank 100 feet below the ferry and set 1 foot lower than the gage at the Southern Railway bridge. On June 1, 1899, the lower gage was discontinued and the upper gage resumed and adopted by the United States Weather Bureau, the United States Geological Survey still receiving the records and making the current-meter discharge measurements at this point. The gage now used is in two sections, the first, reading from zero to 8 feet, fastened to a willow tree 100 feet above the bridge on the left bank; the second, reading from 8 to 26 feet, fastened to an ash tree 30 feet above the bridge on the left bank. It is set on the same datum as the old wire gage of the United States Geological Survey established at that point by Mr. Babb in 1895 and above referred to. Its zero point is 753.5 feet above sea level. Discharge measurements are made from the railway bridge. The initial point for soundings is the end of the iron bridge on the right bank, upstream side.

Bench mark No. 1 is a railroad spike in the corner of the pier on the right bank 12.39 feet above datum of gage. Bench mark No. 2 is a large bridge spike in a sycamore tree about 50 feet above the bridge on the left bank; it is at an elevation of 11.00 feet above the zero of the gage. Bench mark No. 3, determined by measuring down to the water, is the top of the iron girder, 40 feet from the initial point for soundings, on the upstream side of the bridge. Its elevation is 57.55 feet above the zero of the gage. The flow is obstructed by rafts, which have to be cleared from the channel occasionally. The channel is straight and the current swift. The banks are subject to overflow. The bed of the stream is constant and the results are fairly good except at high stages, when the water flows through the trestlework. The observer is J. B. Austin.

This station was discontinued by the Weather Bureau on November 30, 1904, but the single daily readings for several months before that time are not considered reliable as representing the flow of the river on account of the operation of a large water-power plant above. Only the records for the first five months of the year are used.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Chattahoochee River at Oakdale, Ga., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
March 2	M. R. Hall		2,644	3.70	9.95	9,787
March 23	J. M. Giles		8,553	3.93	21.85	33,620
April 23	E. C. Murphy and M. R. Hall.		1,598	3.03	5.03	4,836
June 2	J. M. Giles		3,240	3.85	12.20	12,484
September 2	do		809	2.00	1.25	1,612
October 7	do		622	2.18	1.10	1,359
November 5	do		828	2.27	1.90	1,882
1904.						
February 11	J. M. Giles	221	1,225	2.39	3.28	2,929
March 15	do	224	1,277	2.53	3.50	3,233
May 3	do	198	723	1.88	1.38	1,360
June 29	J. M. Giles and B. S. Drane.	187	556	1.85	.60	1,029

Mean daily gage height, in feet, of Chattahoochee River at Oakdale, Ga., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	Day.	Jan.	Feb.	Mar.	Apr.	May.
1	1.3	1.6	2.0	2.0	1.5	17	1.7	1.6	2.5	2.0	1.5
2	1.3	1.5	2.3	2.0	1.5	18	1.5	1.6	2.0	2.0	1.5
3	1.7	1.7	2.4	1.9	1.4	19	1.9	1.7	2.0	1.8	1.4
4	1.3	1.5	2.4	1.8	1.4	20	1.6	2.5	2.0	1.7	1.3
5	1.3	1.5	2.0	1.8	1.4	21	1.5	2.7	1.8	1.7	1.3
6	1.3	1.5	2.3	1.5	1.4	22	1.7	4.5	2.0	1.7	1.0
7	1.4	1.6	4.5	1.7	1.4	23	4.0	7.7	3.8	1.7	1.0
8	1.4	3.6	8.2	2.5	1.8	24	4.0	4.3	4.0	1.5	1.0
9	1.3	3.0	4.0	3.0	4.0	25	3.5	3.5	4.4	1.5	1.0
10	1.4	3.6	3.0	5.0	4.5	26	3.0	3.0	4.0	1.5	.8
11	1.4	4.0	2.8	3.0	2.7	27	3.0	2.8	3.0	1.7	.8
12	1.3	2.7	2.5	2.5	2.0	28	3.0	2.4	2.6	1.7	.8
13	1.5	2.0	2.2	2.2	1.8	29	3.5	2.0	2.3	1.5	.8
14	1.6	1.8	2.5	2.0	1.7	30	3.6	.....	2.0	1.5	1.0
15	1.5	2.0	4.5	1.9	1.7	31	1.6	.....	1.8	.....	1.7
16	1.5	1.9	3.0	1.9	1.7						

Rating table for Chattahoochee River at Oakdale, Ga., from January 1, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.00	1,300	3.00	2,730	9.00	8,940	16.50	18,650
1.10	1,360	3.20	2,900	9.50	9,540	17.00	19,400
1.20	1,420	3.40	3,080	10.00	10,140	17.50	20,160
1.30	1,480	3.60	3,260	10.50	10,740	18.00	20,960
1.40	1,545	3.80	3,450	11.00	11,340	18.50	21,800
1.50	1,610	4.00	3,640	11.50	11,940	19.00	22,800
1.60	1,675	4.50	4,140	12.00	12,540	19.50	23,800
1.70	1,740	5.00	4,640	12.50	13,190	20.00	25,000
1.80	1,810	5.50	5,140	13.00	13,840	20.50	26,300
1.90	1,880	6.00	5,640	13.50	14,490	21.00	27,800
2.00	1,950	6.50	6,190	14.00	15,140	21.50	29,550
2.20	2,095	7.00	6,740	14.50	15,840	22.00	31,300
2.40	2,245	7.50	7,290	15.00	16,540	23.00	34,800
2.60	2,400	8.00	7,840	15.50	17,240	24.00	38,300
2.80	2,560	8.50	8,390	16.00	17,940		

The above table is based upon discharge measurements made during 1902–1904. It is well defined between gage heights 0.6 feet and 12 feet. Above that point the table is based upon four scattered measurements.

Estimated monthly discharge of Chattahoochee River at Oakdale, Ga., for 1904.

[Drainage area, 1,560 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	3,640	1,480	1,993	1.28	1.48
February	7,510	1,610	2,504	1.61	1.74
March	8,060	1,810	2,749	1.76	2.03
April	4,640	1,610	1,983	1.27	1.42
May	4,140	1,180	1,699	1.09	1.26

CHATTAHOOCHEE RIVER AT WEST POINT, GA.

This station was established July 30, 1896, by M. R. Hall, and the gage is now maintained by the United States Weather Bureau. It is located at Montgomery street wagon bridge. The boxed chain gage is securely bolted to the outside of the iron railing of the downstream footway at a point 122 to 124 feet from the initial point for soundings. The boxed gage is so constructed that the length of the chain is always 2 feet greater than the elevation of the bottom of the box above gage datum. The length of the chain is 29.26 feet from the end of the weight to the marker. The wagon bridge from which discharge measurements are made is in three spans, with short approaches from each end. The floor of the bridge is about 24 feet above low water. The initial point for soundings is the end of the hand rail on the right bank, downstream side of the bridge. The channel is straight for about 2,000 feet above and 3,000 feet below the station. The current has a fair velocity, except at low stages. The right bank is high and overflows only at high water, when most of the town is covered. The left bank is somewhat lower and overflows for about 800 feet at a gage height of 20 feet. The bed of the stream is of sand and gravel and is unstable.

Bench mark No. 1 is the top of the downstream end of the second iron floor beam under the bridge floor from the right-bank end of the highway bridge. Its elevation is 24.19 feet above gage datum. Bench mark No. 2 is the top of the thirty-eighth milepost on the Franklin and West Point survey of the United States engineers. This post is a cast-iron cap 6 inches square, set in concrete, and approximately on a level with the ground. It is marked "U. S. 38." A raised point in the center of the cap is the bench mark; its elevation is 15.68 feet above gage datum. The location of this post is on the right bank of the river, 340 feet upstream from the wagon bridge and 50 feet from the edge of the river. It is 60 feet south of the Episco-

pal church, and is 132 feet east of the northeast corner of a lot belonging to W. G. Sheafers, which is the southwest corner of Jasper and Front streets. Bench mark No. 3 is the top of the first marble block and bottom of the second marble block of the Confederate monument in the center of the street, 1,300 feet from the initial point of soundings and 860 feet from the east end of the bridge. Its elevation is 25.56 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Chattahoochee River at Westpoint, Ga., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
January 6	M. R. Hall	383	3,550	1.42	3.95	5,056
April 22	E. C. Murphy & M. R. Hall.	394	4,040	2.16	5.39	8,713
June 5	M. R. Hall	381	5,458	3.84	9.70	20,960
June 6	do	386	6,046	4.24	11.30	25,620
July 30	J. M. Giles	358	3,312	1.44	3.46	4,761
July 31	do	356	3,569	1.68	4.07	5,993
September 23	M. R. Hall	375	2,875	.85	2.40	2,451
September 24	do	369	2,858	.85	2.32	2,416
December 17	W. E. Hall	376	2,901	.85	2.37	2,460
1904.						
February 3–4	W. E. Hall	376	3,101	.97	2.80	3,005
April 7	J. M. Giles	377	2,781	1.13	2.83	3,144
April 7	do	377	2,787	1.13	2.88	3,155
April 14	do	377	2,805	1.13	2.90	3,179
April 14	do	377	2,785	1.14	2.90	3,180
June 20	do	353	2,223	.58	1.56	1,298
June 20	do	353	2,228	.59	1.56	1,306
September 2	W. E. Hall	368	2,397	.50	1.46	1,203
September 3	do	371	2,621	.71	2.00	1,862
September 29	J. M. Giles	368	2,451	.41	1.20	1,005
September 30	do	368	2,474	.41	1.27	1,010
December 6	W. E. Hall	380	2,933	.96	2.70	2,808

Mean daily gage height, in feet, of Chattahoochee River at Westpoint, Ga., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.4	2.9	3.3	2.9	2.5	3.0	2.5	2.6	2.3	1.2	1.2	1.7
2	2.3	2.9	3.3	2.9	2.5	3.6	2.3	2.7	1.4	1.2	.9	1.8
3	2.4	2.9	3.7	2.9	2.4	2.7	2.1	2.5	2.0	1.2	1.1	1.9
4	2.4	2.8	3.5	2.8	2.4	2.4	2.1	3.3	1.9	1.2	1.5	2.0
5	2.4	2.8	3.3	2.7	2.4	2.2	1.7	2.5	1.8	1.1	1.7	2.0
6	2.3	2.8	3.1	2.7	2.4	2.1	1.9	3.1	2.5	1.1	1.6	2.8
7	2.3	3.1	4.7	2.8	2.4	1.5	1.6	5.3	2.4	1.2	1.6	3.1
8	2.4	4.8	6.0	3.2	2.4	1.4	1.3	11.4	2.2	1.2	1.5	3.2
9	2.4	5.0	6.0	3.6	2.4	2.0	2.4	12.6	2.1	1.1	1.6	3.1
10	2.7	4.4	5.4	3.5	3.1	2.3	2.1	12.4	1.9	1.1	1.5	2.7
11	3.0	5.4	4.2	3.5	3.4	2.1	1.8	9.6	1.7	1.1	1.5	2.5
12	2.8	5.1	3.7	3.4	3.1	2.0	1.6	6.2	1.6	1.1	1.5	2.1
13	2.7	4.1	3.6	3.1	2.6	1.8	1.6	4.8	1.6	1.2	1.6	1.9
14	2.7	3.7	3.6	2.9	2.4	1.6	1.8	4.2	1.6	1.1	1.7	2.0
15	2.7	3.4	4.0	2.8	2.3	1.6	1.9	5.0	1.5	1.0	1.8	1.8
16	2.6	3.3	4.2	2.7	2.3	1.6	1.4	4.0	1.5	1.0	1.7	1.8
17	3.5	3.2	3.7	2.7	2.3	1.6	1.4	3.9	1.4	1.0	1.6	1.8
18	3.6	3.0	3.4	2.7	2.3	1.5	1.7	3.4	1.4	1.1	1.6	1.8
19	3.3	3.1	3.2	2.7	2.2	1.5	1.4	3.0	1.4	1.0	1.6	1.8
20	3.1	3.7	3.1	2.7	2.1	1.5	2.0	2.9	1.3	1.1	1.6	1.8
21	2.8	4.0	3.0	2.7	2.0	1.5	1.7	2.3	1.3	1.2	1.6	1.7
22	3.3	5.4	3.0	2.7	2.0	1.4	2.0	2.4	1.4	.9	1.6	1.7
23	5.5	6.4	3.3	2.7	2.0	1.3	2.1	2.2	1.8	.9	1.8	1.7
24	5.1	6.1	3.3	2.6	1.9	1.7	2.3	2.2	1.9	.9	1.8	1.7
25	4.2	5.3	3.8	2.6	1.9	1.3	2.0	4.3	1.5	.9	1.8	1.9
26	3.8	4.3	3.8	2.6	1.9	1.4	1.9	5.1	1.4	.9	1.8	2.1
27	3.3	3.9	3.6	2.6	1.8	1.3	1.4	4.1	1.3	1.1	1.7	2.1
28	3.0	3.6	3.3	2.6	1.8	1.2	1.9	5.8	1.3	1.2	1.7	3.5
29	3.0	3.4	3.2	2.6	1.8	1.4	1.7	3.9	1.3	1.1	1.7	3.6
30	2.9	.....	3.1	2.6	1.8	2.0	2.1	3.0	1.3	1.0	1.6	3.7
31	2.9	.....	3.0	.....	2.7	.....	2.2	2.4	.....	1.1	.....	3.5

Rating table for Chattahoochee River at Westpoint, Ga., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet*
0.90	800	2.00	1,840	4.20	5,830	6.40	11,380
1.00	850	2.20	2,100	4.40	6,290	6.60	11,940
1.10	920	2.40	2,380	4.60	6,760	6.80	12,520
1.20	1,000	2.60	2,680	4.80	7,240	7.00	13,100
1.30	1,090	2.80	3,000	5.00	7,740	8.00	16,000
1.40	1,180	3.00	3,340	5.20	8,240	9.00	18,900
1.50	1,280	3.20	3,700	5.40	8,740	10.00	21,800
1.60	1,380	3.40	4,080	5.60	9,260	11.00	24,700
1.70	1,490	3.60	4,500	5.80	9,780		
1.80	1,600	3.80	4,940	6.00	10,300		
1.90	1,720	4.00	5,380	6.20	10,840		

The foregoing table is based upon discharge measurements made during 1903 and 1904. It is well defined between gage heights 1.20 feet and 11.40 feet. The table has been extended beyond these limits. Above gage height 6.50 feet the rating curve is a tangent, the difference being 290 per tenth.

Estimated monthly discharge of Chattahoochee River at Westpoint, Ga., for 1904.

[Drainage area, 3,300 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	9,000	2,240	3,520	1.07	1.23
February	11,380	3,000	5,447	1.65	1.78
March	10,300	3,340	4,858	1.47	1.70
April	4,500	2,680	3,107	.942	1.05
May	4,080	1,600	2,285	.692	.798
June	4,500	1,000	1,695	.514	.574
July	2,530	1,090	1,705	.517	.596
August	29,340	2,100	7,515	2.28	2.63
September	2,530	1,090	1,484	.450	.502
October	1,000	800	913	.277	.319
November	1,600	800	1,375	.417	.465
December	4,720	1,490	2,294	.695	.801
The year	29,340	800	3,016	.914	12.44

SOQUE RIVER NEAR DEMOREST, GA.

This station was established July 16, 1904, by M. R. Hall. It is located at Cannon Bridge on road from Cornelia to Acorn, 2½ miles from Demorest and about 4 miles above the mouth of the river. The gage is a vertical 10-foot timber fastened to a scantling which is spiked to the sill and upstream post of trestle bent at the left bank. It is graduated to feet and tenths. The gage is read once each day by Charles Cannon. This station is maintained in cooperation with the Georgia Geological Survey, by whom the gage reader is paid. Discharge measurements are made from the single-span, wooden, wagon bridge, to which the gage is attached. The bridge has a 28-foot approach on the left bank and 90-foot approach on the right bank. The initial point for soundings is the end of the bridge on the upstream side at the left bank. The channel is curved for 500 feet above and slightly curved for 500 feet below the station. The current is swift. Both banks are high and wooded. The right bank overflows during extreme high water. The bed of the stream is composed largely of rock and is permanent. There is but one channel at all stages. Bench mark No. 1 is the top of the upstream end

of the right bank wooden pier, and is marked with white paint. Its elevation is 21.30 feet above the zero of the gage. Bench mark No. 2 is a nail in an ironwood tree 20 feet above bridge on the right bank. Its elevation is 6.00 feet above the zero of the gage.

Discharge measurements of Soque River near Demorest, Ga., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
June 8	J. M. Giles	74	159	1.14	1.74	182
July 16	M. R. Hall	74	139	.88	1.46	123
August 24	W. E. Hall	81	209	.97	1.81	202
October 28	M. R. Hall	81	169	.60	1.31	102
October 28	do	81	169	.60	1.31	101
November 23	W. E. Hall	80	192	.78	1.58	150

Mean daily gage height, in feet, of Soque River near Demorest, Ga., for 1904.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	1.25	1.65	1.40	1.35	1.40	17	1.40	1.80	1.50	1.30	1.40	1.50
2	.....	2.10	1.65	1.35	1.40	1.40	18	1.35	1.80	1.45	1.30	1.40	1.50
3	.....	2.15	1.60	1.35	1.40	1.45	19	1.40	1.75	1.50	1.30	1.40	1.55
4	.....	1.70	2.75	1.35	1.65	1.55	20	1.40	2.20	1.45	1.30	1.40	1.50
5	.....	2.00	2.60	1.35	1.60	3.05	21	1.40	1.75	1.60	1.25	1.40	1.50
6	.....	3.45	2.00	1.35	1.50	2.30	22	3.70	1.70	1.50	1.25	1.45	1.45
7	.....	1.60	1.85	1.40	1.40	1.70	23	1.55	1.60	1.40	1.30	1.60	1.45
8	.....	5.25	2.10	1.40	1.40	1.65	24	1.50	1.65	1.40	1.30	1.65	1.45
9	.....	2.90	1.85	1.35	1.35	1.55	25	2.30	2.30	1.45	1.30	1.50	1.70
10	.....	2.70	1.70	1.40	1.35	1.50	26	1.60	2.35	1.45	1.30	1.45	1.65
11	.....	1.95	1.60	1.35	1.35	1.45	27	1.45	2.40	1.50	1.30	1.40	2.00
12	.....	2.40	1.60	1.35	1.40	1.45	28	1.40	2.10	1.45	1.30	1.40	2.30
13	.....	2.00	1.60	1.35	1.45	1.55	29	1.65	2.00	1.40	1.30	1.40	2.10
14	.....	1.95	1.55	1.35	1.45	1.50	30	1.50	1.75	1.40	1.30	1.40	1.85
15	.....	1.80	1.50	1.30	1.40	1.50	31	2.70	1.70	.....	1.35	.....	1.70
16	1.45	1.85	1.50	1.30	1.40	1.50							

Rating table for Soque River near Demorest, Ga., from July 16 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.25	93	1.50	132	1.80	198	2.10	282
1.30	100	1.60	152	1.90	224	2.20	314
1.40	115	1.70	174	2.00	252		

The above table is based upon six discharge measurements made during 1904 and one measurement made in 1905. It is well defined between gage heights 1.30 feet and 2.20 feet. Estimates made above 2.50 feet can only be considered a rough approximation.

Estimated monthly discharge of Soque River near Demorest, Ga., for 1904.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
July (16–31)	980	108	218
August	1,745	93	322
September	525	115	174
October	115	93	104
November	163	108	122
December	666	115	183

SWEETWATER CREEK NEAR AUSTELL, GA.

This station was established May 6, 1904, by M. R. Hall. It is located at the south side of Lithia Springs Park, near Austell, Ga. The station is maintained in cooperation with the Georgia Geological Survey, by whom the gage reader is paid. The gage is composed of two sections. The first or inclined section, graduated by tenths to 8 feet, is bolted to a large rock on the right bank. The second or vertical section, graduated from 8 to 16 feet, is spiked to a maple tree on the right bank about 100 feet upstream. The gage is read twice each day by J. L. Causey. Discharge measurements are made from a boat at low and ordinary stages about 400 yards below the gage. High-water measurements are made from Strickland's wagon bridge, 1½ miles downstream. The channel is straight for about 300 feet above and for 200 feet below the gage. The current above the gage is sluggish; below the gage it is swift for about 50 feet, at several places with sluggish water between. Both banks are high and wooded, the right being composed of rock, and are not liable to overflow. There is but one channel at all stages. Bench mark No. 1 is a nail in a small maple on the right bank about 200 feet below the gage. Its elevation is 5.00 feet above the zero of the gage. Bench mark No. 2 is a cross cut on a large rock about 10 feet south of the sloping section of the gage. Its elevation is 10.00 feet about the zero of the gage.

Discharge measurements of Sweetwater Creek near Austell, Ga., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
May 6 [a]	W. E. and M. R. Hall.	42	148	0.82	1.68	122
June 16 [b]	J. M. Giles	45	71	.85	1.15	61
June 16 [a]	do	41	119	.54	1.20	64
July 9 [a]	W. E. Hall	43	140	.61	1.40	85
July 29 [a]	J. M. Giles	54	201	1.26	2.70	254
August 30 [a]	W. E. Hall	53	194	.92	2.35	178
August 31 [c]	J. M. Giles	45	99	1.24	1.96	122
October 1 [d]	M. R. Hall	55	105	.58	1.24	61
October 1 [d]	do	55	104	.58	1.28	60

[a] Strickland's bridge.
[b] Boat 100 yards below gage.
[c] Wading 100 yards below gage.
[d] 1,000 feet above gage.

Mean daily gage height, in feet, of Sweetwater Creek near Austell, Ga., for 1904.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.40	1.90	1.50	1.90	0.90	0.90	1.65
2	.....	2.50	1.45	1.60	1.70	.65	1.05	1.60
3	.....	1.90	1.30	4.40	1.60	1.05	.95	1.85
4	.....	1.60	1.25	2.90	3.00	.70	1.60	1.85
5	.....	1.50	1.20	3.90	2.65	1.05	1.80	2.50
6	.....	1.50	1.10	3.85	2.05	.75	1.70	3.65
7	.....	1.95	1.05	2.30	1.70	.95	1.40	2.60
8	.....	1.70	1.35	11.90	1.65	.90	1.35	2.25
9	.....	1.45	1.35	16.30	1.60	.65	1.25	2.05
10	.....	1.30	1.15	11.40	1.45	.90	1.25	2.05
11	.....	1.20	1.10	4.95	1.40	.90	1.25	2.20
12	.....	1.20	1.05	6.30	1.30	.85	1.30	2.00
13	.....	1.10	1.15	4.30	1.25	.90	1.65	1.85
14	.....	1.00	.90	3.45	1.25	.95	2.10	1.75
15	.....	1.00	1.00	3.25	1.35	.85	1.75	1.75
16	.....	1.15	1.05	4.55	1.10	.55	1.45	1.90
17	.....	1.00	.55	3.20	.90	1.00	1.40	1.85
18	1.50	1.00	1.00	3.45	1.20	.70	1.35	1.75
19	1.50	1.00	.75	2.40	1.20	.70	1.45	1.90
20	1.45	1.90	.75	1.95	1.05	.85	1.40	1.65
21	1.45	2.80	.75	2.15	1.10	.70	1.45	1.65
22	1.35	3.50	.90	2.00	1.10	.75	1.80	1.60
23	1.30	2.15	1.15	1.95	1.00	.60	2.40	1.70
24	1.30	1.70	.70	2.65	1.15	1.00	2.00	1.65
25	1.25	1.30	1.05	4.05	1.00	.90	1.75	1.65
26	1.15	1.15	1.00	5.50	1.05	.90	1.60	1.65
27	1.20	1.20	.90	7.15	.85	.85	1.45	1.75
28	1.20	2.40	1.25	6.00	1.10	.85	1.60	3.45
29	1.15	5.60	2.50	3.10	1.05	.90	1.50	3.25
30	1.30	2.85	2.20	2.35	.95	.50	1.50	3.20
31	2.55	.....	1.65	2.10	.....	.95	.....	2.50

MULBERRY CREEK NEAR COLUMBUS, GA.

This station was established as a bench-mark station June 23, 1904, by W. E. Hall. It is located at Mitchell's bridge, about 16 miles north of Columbus, Ga., and 12 miles south of Hamilton, Ga. Mulberry Creek is a tributary of Chattahoochee River, which it enters about 6 miles to the west of the station. Discharge measurements are made from the downstream side of the two-span open wooden truss highway bridge, resting upon stone abutments and center wooden pile bent. The initial point for soundings is the left end of the bridge on the downstream side. The channel is straight for about 50 feet above and 200 feet below the bridge. The current is rather sluggish above and swift below the station. Both banks are high and not liable to overflow. The right bank is clean; the left bank is wooded and covered with brush. The bed of the stream is composed of rock and sand. There is but one channel at all stages, broken by one wooden pier. The bottom is very uneven, causing the currents to change directions during low water. The bench mark is the top of the downstream end of the wooden cap of center pile bent. Its elevation is 32.00 feet above datum.

Discharge measurements of Mulberry Creek near Columbus, Ga., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
June 23	W. E. Hall	38	62	0.92	1.40	58
September 21	do	32	47	.68	1.23	32
September 21	do	32	47	.70	1.23	33

FLINT RIVER NEAR WOODBURY, GA.

Measurements of the flow of Flint River were made during 1897 and 1898 at Molina, Ga., but the river bed was so shifting that the station was discontinued on June 2, 1898. Two measurements were made in 1899 at the Macon and Birmingham Railroad bridge, near Woodbury, Ga., 5 miles below the Molena station. On March 29, 1900, a gage was put in near this bridge, and the station was reestablished.

The gage is graduated on a 1 by 5 inch plank in 5-foot sections; the part reading from zero to 10 feet is attached to a willow tree on the left bank about 300 feet above the bridge and about 50 feet below Riggins's old ferry; the section reading from 10 to 15 feet is fastened to a sweet gum tree 50 feet from the left bank and 150 feet upstream from the bridge. This gage was maintained by the Georgia Geological Survey until November 1, 1900, when it was adopted by the United States Weather Bureau instead of the one at Reynolds, Ga. The

observer is G. A. Wright, who is paid by the United States Weather Bureau. Discharge measurements are made from the Macon and Birmingham Railroad bridge and its trestle approaches. This is a two-span iron bridge, each span being 150 feet long and supported by brick piers. There are wooden trestle approaches about 150 feet on the right bank and 225 feet on the left. The initial point for soundings is the end of the iron bridge on the right bank, downstream side. The bridge and its piers are oblique to the direction of the current, and the bed is rough and irregular and mostly permanent. The channel above and below the station is slightly curved for 800 feet. Above ten feet the banks are subject to overflow for a width of 300 or 400 feet, but all water passes beneath the bridge and its approaches.

Bench mark No. 1 is the top of the downstream end of the second and third crossbeams from the left bank end of the bridge. The elevation of this bench mark is 27.00 feet above the zero of the gage. Bench mark No. 2 is a cut in the hickory tree on the upstream side of the old ferry landing, 50 feet from the left bank of the river and about 75 feet upstream from the gage. Its elevation is 7.00 feet above the zero of the gage. Bench mark No. 3 is a copper plug set in solid rock on the west side of the river about 100 feet from the water and 100 feet upstream from a point opposite the gage. Its elevation is 16.24 feet above the zero of the gage. The zero of the gage is at an elevation of 660 feet above sea level.

The observations at the station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Flint River near Woodbury, Ga., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
April 22	E. C. Murphy		1,145	2.34	2.45	2,679
February 12[a]	M. R. Hall		2,974	5.48	9.20	16,290
March 26	J. M. Giles		2,104	4.21	5.45	8,861
June 29	do		1,042	1.53	1.48	1,591
July 30	do		704	.71	.37	500
September 30	M. R. Hall		690	.56	.28	387
1904.						
February 11	F. A. Murray	255	1,350	2.29	2.81	3,085
February 23	W. E. Hall	247	1,478	2.78	3.30	4,114
March 30	J. M. Giles	218	757	.82	.74	620
July 7	W. E. Hall	238	694	.37	.00	256
August 25	B. S. Drane	291	745	.51	.30	383
October 4[b]	J. M. Giles	208	345	.51	— .25	178

[a] This is a flood measurement. Stage being high for this station. Results considered fairly accurate.
[b] Taken from boat one-half mile above bridge.

Mean daily gage height, in feet, of Flint River near Woodbury, Ga., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.50	0.90	1.20	0.70	0.40	1.10	0.30	0.40	0.20	— .25	—0.35	0.10
2	.50	.90	1.30	.60	.40	1.00	.20	1.30	.10	— .30	— .30	.20
3	.60	.80	1.50	.70	.50	.80	.10	1.10	.10	— .30	— .20	.30
4	.70	.70	1.60	.60	.60	.50	.10	1.20	.50	— .30	.00	.40
5	.60	.80	2.00	.60	.50	.30	.00	2.20	.80	— .30	.00	.50
6	.50	.70	2.50	.70	.50	1.00	.00	2.10	.70	— .35	.10	.90
7	.60	.80	2.30	.80	.40	.80	.00	2.20	.30	— .35	.00	.90
8	.70	2.60	2.20	.90	.30	.60	— .05	8.70	.20	— .40	.00	.70
9	.60	2.50	2.10	1.90	.20	.50	.10	6.50	.20	— .40	— .10	.50
10	.80	2.30	1.90	1.40	.30	.40	.10	5.00	.10	— .40	— .05	.50
11	1.20	2.80	1.50	1.00	.30	.40	.60	5.00	.00	— .35	— .05	.40
12	1.00	2.50	1.30	.80	.30	.00	.30	3.50	.00	— .35	— .05	.30
13	.90	2.20	1.10	.70	.20	.00	.20	3.00	.00	— .40	.10	.30
14	.80	2.00	1.20	.60	.10	.00	.20	1.20	— .05	— .40	.20	.30
15	.70	1.70	1.40	.60	.20	— .05[a]	.00	1.50	— .10	— .40	.20	.30
16	.80	1.40	1.20	.60	.20	— .05	— .05	1.40	— .10	— .40	.10	.30
17	1.30	1.20	1.00	.50	.10	— .05	— .10	.90	— .10	— .45	.10	.30
18	1.50	1.10	1.00	.50	.20	— .05	— .10	.50	— .10	— .45	.10	.20
19	1.40	1.20	.90	.40	.10	— .05	.10	.50	— .15	— .40	.10	.20
20	1.20	1.40	.90	.50	.10	— .05	.10	.40	— .20	— .40	.00	.20
21	1.00	1.50	.80	.40	.10	— .05	— .05	.30	— .15	— .45	.00	.20
22	1.10	2.60	.90	.40	.00	— .05	.20	.30	— .15	— .45	.10	.30
23	3.20	3.00	.90	.50	.00	— .05	.10	.30	— .20	— .45	.10	.20
24	3.00	2.90	.90	.40	.00	— .05	.80	.40	— .25	— .50	.20	.20
25	2.70	2.50	.80	.50	.00	— .05	1.00	.30	— .15	— .45	.20	.40
26	1.90	2.00	.90	.40	.00	.00	.40	.70	— .30	— .40	.10	.50
27	1.50	1.90	.90	.50	.00	.00	.20	.10	— .20	— .35	.10	.60
28	1.20	1.40	.80	.40	.00	.00	.10	.30	— .20	— .40	.10	1.30
29	1.10	1.20	.90	.40	.00	.40	.00	.60	— .25	— .35	.10	1.50
30	1.00	.....	.80	.50	.00	.40	.10	.50	— .25	— .35	.10	1.30
31	.90	.....	.80	.....	1.00	.....	.20	.30	.....	— .40	.....	1.10

[a] June 15 to 25 observer reported "below zero" but stated afterward that he did not think it went as much as 1 tenth below.

Rating table for Flint River near Woodbury, Ga., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
—0.50	120	1.00	1,005	3.00	3,410	5.00	6,520
— .45	135	1.10	1,115	3.10	3,545	5.20	6,880
— .40	150	1.20	1,225	3.20	3,680	5.40	7,200
— .35	165	1.30	1,340	3.30	3,820	5.60	7,640
— .30	180	1.40	1,455	3.40	3,960	5.80	8,040
— .25	195	1.50	1,570	3.50	4,100	6.00	8,450
— .20	210	1.60	1,685	3.60	4,240	6.20	8,880
— .15	225	1.70	1,800	3.70	4,390	6.40	9,320
— .10	240	1.80	1,920	3.80	4,540	6.60	9,780
— .05	260	1.90	2,040	3.90	4,690	6.80	10,260
.00	280	2.00	2,160	4.00	4,840	7.00	10,750
.10	320	2.10	2,280	4.10	5,000	7.20	11,250
.20	360	2.20	2,400	4.20	5,160	7.40	11,750
.30	410	2.30	2,520	4.30	5,320	7.60	12,250
.40	470	2.40	2,640	4.40	5,480	7.80	12,750
.50	540	2.50	2,760	4.50	5,650	8.00	13,250
.60	620	2.60	2,890	4.60	5,820	8.50	14,500
.70	705	2.70	3,020	4.70	5,990	9.00	15,750
.80	800	2.80	3,150	4.80	6,160	9.50	17,000
.90	900	2.90	3,280	4.90	6,340	10.00	18,250

The above table is well defined between —0.2 feet and 4.5 feet. Above this point the table is based on one measurement at 9.2 feet. It is based upon discharge measurements made during 1901–1904.

Estimated monthly discharge of Flint River near Woodbury, Ga., for 1904.

[Drainage area, 988 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	3,680	540	1,207	1.22	1.41
February	3,410	705	1,838	1.86	2.01
March	2,760	800	1,326	1.34	1.55
April	2,040	470	687	.695	.775
May	1,005	280	394	.399	.460
June	1,115	260	442	.447	.499
July	1,005	240	368	.372	.429
August	15,000	320	2,198	2.22	2.56
September	800	180	302	.306	.341
October	195	120	155	.157	.181
November	360	165	295	.299	.334
December	1,570	320	586	.593	.684
The year	15,000	120	816	.826	11.23

FLINT RIVER AT ALBANY, GA.

This station was originally established by the United States Weather Bureau on April 10, 1893, and has been maintained from that date to the present. The gage was washed out and replaced in 1898. It was again injured in 1902, and was replaced by a new gage on June 17, 1902, which was read for the first time on June 18. The new gage was set seventy-five hundredths of a foot lower than the old gage. The gage as it existed prior to June 17, 1902, is described in Water-Supply Paper No. 48, page 156. R. V. Watson was employed by the Weather Bureau to make and set the new gage, and it appears from Mr. Watson's description of this gage on June 17, 1902, that a certain bench mark cut in the lower iron pier of the county bridge and described in Paper No. 48, above referred to, as being 10 feet above zero of gage, was in reality only 9 feet and 3 inches above the zero of the old gage. As Mr. Watson set the new gage 10 feet below this bench mark, its zero is 9 inches lower than that of the old gage. The gage heights have been corrected from January 1 to June 17, 1902, inclusive, to correspond with the new gage, so that one rating table will apply to the whole year.

The following is Mr. Watson's description of the United States Weather Bureau gage: The name of the bridge to which the gage is attached is the Dougherty County Flint River Bridge, located at

Albany, Ga., about 700 feet below the Atlantic Coast Line Railway bridge. The gage is in three parts or sections. No. 1 is attached to the crib around the middle piers (the crib is filled with rocks, being 30 by 14 feet), and extends about 3 feet above ordinary low water. This section reads to 4 feet above zero. It is securely spiked to the wooden crib. Section No. 2 is securely spiked to a green cypress tree just above the bridge on the west bank of the river, and reads from 2 to 17 feet above the zero on No. 1. No. 3 is securely spiked to a cedar post 16 feet high, the post being put 3 feet into the firm ground. This section begins at 17 feet above the zero on No. 1 and reads to 32 feet, which is about 2½ feet above any high water known since 1840.

A 24-inch iron top locked box chain gage belonging to the United States Geological Survey was put in by W. E. Hall on April 20, 1904. The box is securely bolted to the iron lattice of the hand railing of the downstream footway of the Dougherty County Bridge, near the middle part of the west span of the bridge. The graduated scale is 24 feet long, and is bolted to the same latticework, the zero end being in contact with the end of the box, and the scale extending west toward the right bank. This gage was accurately set to correspond with the bench marks previously established, and its readings agree with the standard portion of the Weather Bureau gage. The bottom of the box is 45.34 feet above the zero of the gage, and the length of the chain from the bottom of the weight to the marker is 47.34 feet.

Discharge measurements by the Geological Survey were begun at this station in 1901, and the gage height records furnished by the Weather Bureau have been used, except for a portion of the year 1903. The present observer, D. W. Brosnan, is now paid by the United States Weather Bureau.

Discharge measurements are made from the two-span railroad bridge of the Atlantic Coast Line, which is 325 feet long, with 475 feet of trestle approach on the right bank and 240 feet on the left bank.

The initial point for soundings is the center of the tubular iron pier on the upstream side of the bridge on the left bank. The channel above the station is straight for about 1,000 feet and is rough. Below the station the channel is straight for 700 feet. The river overflows both banks, but only under the approaches to the bridge. The bed is constant, but is rough, and the current is irregular.

Bench mark No. 1 is a copper plug set in the downstream corner of the brick abutment on the right bank, under the Dougherty County Bridge. Its elevation is 33.81 feet above the zero of the gage. Bench mark No. 2 is the top of the first crossbeam from the right bank, upstream end of the railroad bridge. Its elevation is 43.20 feet above the zero of the gage. Bench mark No. 3 is a chisel mark on the tubular pier of the wagon bridge on the right bank, downstream side.

Its elevation is 10.00 feet above the zero of the gage. Bench mark No. 4 is the top of the third granite block of the Confederate monument at the center of Jackson and Pine streets. This is at the bottom of the polished block which bears the inscription. Its elevation is 61.09 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Flint River at Albany, Ga., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
March 6	F. A. Murray		4,249	4.38	13.68	18,630
May 21	M. R. Hall		5,352	4.32	16.80	23,120
July 3	F. A. Murray		2,283	3.38	5.65	7,744
September 18	M. R. Hall		4,124	4.03	13.06	16,640
October 14	do		1,488	2.34	1.90	3,484
December 22	F. A. Murray		1,757	2.92	3.25	5,035
1904.						
April 19	W. E. Hall	227	1,677	2.67	2.78	4,474
June 18	B. S. Drane	264	1,373	1.54	.25	2,111
September 22	J. M. Giles	221	1,342	1.52	.20	2,044
September 23	do	221	1,351	1.56	.20	2,104
November 15	B. S. Drane	271	1,455	2.08	1.11	3,030
November 16	do	271	1,428	2.14	1.20	3,056
November 21	do	269	1,384	1.86	.63	2,423
November 21	do	269	1,353	1.88	.61	2,378

Mean daily gage height, in feet, of Flint River at Albany, Ga., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.2	6.3	8.2	4.2	2.0	0.9	0.5	1.1	5.3	−0.1	−0.3	[illegible]
2	4.4	5.9	7.3	3.9	2.0	1.5	1.5	1.6	3.1	− .1	− .3	[illegible]
3	4.2	5.6	6.7	3.7	1.9	2.6	1.5	1.6	2.2	− .1	− .2	[illegible]
4	4.2	5.2	6.4	3.6	1.9	2.7	1.1	2.9	1.8	− .2	.1	[illegible]
5	4.1	5.0	6.3	3.4	2.4	2.4	.8	5.5	1.6	− .3	.5	[illegible]
6	4.0	4.7	6.6	3.2	2.5	1.9	.6	5.9	1.5	− .3	.8	[illegible]
7	3.9	4.8	7.0	3.3	2.2	1.5	.5	5.6	1.7	− .3	.9	[illegible]
8	4.4	5.2	7.3	4.1	1.9	1.3	.5	6.4	2.3	− .3	.8	[illegible]
9	4.7	6.4	7.3	5.0	1.7	1.1	.4	7.2	2.3	− .2	.6	[illegible]
10	5.1	8.8	7.8	5.4	1.6	1.3	.4	7.8	1.9	− .2	.4	[illegible]
11	6.0	12.9	8.1	5.9	1.6	1.2	.4	8.3	1.5	− .2	.3	[illegible]
12	6.4	16.9	8.1	5.9	1.6	1.0	.7	9.4	1.1	− .3	.3	[illegible]
13	7.0	19.2	7.5	5.4	1.5	.8	.9	10.8	1.0	− .3	.4	[illegible]
14	7.0	18.7	6.8	4.7	1.3	.7	1.1	12.2	.7	− .3	.7	[illegible]
15	6.8	17.2	6.4	3.8	1.3	.6	1.4	13.1	.6	− .3	1.1	[illegible]
16	6.4	15.8	6.2	3.4	1.3	.5	1.0	13.2	.6	− .3	1.2	[illegible]
17	6.0	14.8	6.2	3.2	1.4	.4	.7	12.1	.5	− .3	1.1	[illegible]
18	5.9	13.3	6.1	3.0	1.5	.3	.5	8.0	.4	− .4	.9	[illegible]
19	5.8	10.5	5.8	2.7	1.9	.2	.4	4.9	.4	− .4	.8	[illegible]
20	6.0	8.5	5.2	2.5	1.9	.2	.2	4.7	.3	− .4	.7	[illegible]
21	6.0	8.4	5.0	2.4	1.7	.2	.2	2.9	.2	− .4	.7	[illegible]
22	5.8	9.3	4.8	2.4	1.4	.1	.2	2.5	.2	− .4	.6	[illegible]
23	6.8	10.5	4.5	2.4	1.1	.3	.4	2.1	.2	− .4	.7	[illegible]
24	8.1	10.9	4.2	2.3	1.0	.5	.9	2.0	.2	− .4	.9	[illegible]
25	9.5	10.9	4.2	2.3	.8	.5	1.4	2.0	.1	− .4	1.1	[illegible]
26	9.7	10.6	4.1	2.2	.8	.4	1.2	2.2	.1	− .5	1.1	[illegible]
27	10.0	10.4	4.5	2.2	.7	.4	1.0	2.8	.1	− .5	1.0	[illegible]
28	10.4	10.1	5.0	2.1	.6	.3	1.2	4.0	.0	− .5	.9	[illegible]
29	10.3	9.4	4.9	2.0	.5	.3	1.0	4.1	.0	− .4	.7	[illegible]
30	9.0	.....	4.8	2.0	.6	.3	.7	6.0	.0	− .4	.6	[illegible]
31	7.0	.....	4.3	.....	.9	.....	1.0	6.4	.....	− .3	.....	[illegible]

Rating table for Flint River at Albany, Ga., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
—0.50	1,480	1.00	2,780	5.50	7,425	13.00	16,750
— .40	1,560	1.20	2,960	6.00	8,000	13.50	17,525
— .30	1,645	1.40	3,140	6.50	8,575	14.00	18,300
— .20	1,730	1.60	3,330	7.00	9,150	14.50	19,150
— .10	1,815	1.80	3,520	7.50	9,725	15.00	20,000
.00	1,900	2.00	3,710	8.00	10,300	15.50	20,850
.10	1,985	2.20	3,900	8.50	10,900	16.00	21,700
.20	2,070	2.40	4,100	9.00	11,500	16.50	22,550
.30	2,155	2.60	4,300	9.50	12,100	17.00	23,400
.40	2,240	2.80	4,500	10.00	12,700	17.50	24,300
.50	2,330	3.00	4,700	10.50	13,350	18.00	25,200
.60	2,420	3.50	5,225	11.00	14,000	18.50	26,100
.70	2,510	4.00	5,750	11.50	14,675	19.00	27,000
.80	2,600	4.50	6,300	12.00	15,350	19.50	27,950
.90	2,690	5.00	6,850	12.50	16,050	20.00	28,900

The above table is based upon eighteen discharge measurements made during 1902–1904. It is well defined between gage heights 0.0 foot and 6 feet. Above 6 feet the table is approximate.

Estimated monthly discharge of Flint River at Albany, Ga., for 1904.

[Drainage area, 5,000 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	13,220	5,645	8,553	1.71	1.97
February	27,380	6,520	13,550	2.71	2.92
March	10,540	5,860	8,068	1.61	1.86
April	7,885	3,710	5,175	1.04	1.16
May	4,200	2,330	3,215	.643	.741
June	4,400	1,985	2,683	.537	.599
July	3,235	2,070	2,587	.517	.596
August	17,060	2,870	7,949	1.59	1.83
September	7,195	1,900	2,872	.574	.640
October	1,815	1,480	1,629	.326	.376
November	2,960	1,645	2,457	.491	.548
December	5,860	2,330	3,723	.745	.859
The year	27,380	1,480	5,205	1.04	14.10

BIG POTATO CREEK NEAR THOMASTON, GA.

This station was established as a bench-mark station. It is located at the highway bridge, about 5 miles southwest of Thomaston, Ga., 200 yards above Daniel's old gristmill. Discharge measurements are made from the downstream side of the single-span iron bridge, which has trestle approaches of about 100 feet at each end. The initial point for soundings is the left end of the bridge on the downstream side. The channel is curved for about 200 feet above and straight for 300 feet below the station. The current is swift, except at very low stages. Both banks are subject to occasional overflow. The bed of the stream is composed of rock and gravel, free from vegetation, and probably constant. There is but one channel at all stages, broken during the higher water by the piers of the bridge. Bench mark No. 1 is the top of the downstream end of the first floor beam from the left bank. Its elevation is 23.00 feet above datum. Bench mark No. 2 is a chisel mark on the intermediate post at the downstream end of the second floor beam. Its elevation is 28.00 feet above datum.

Discharge measurements of Big Potato Creek near Thomaston, Ga., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge
		Feet.	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet*
March 31	J. M. Giles	87	212	0.77	2.32	[illegible]
May 24	M. R. Hall	85	165	.36	1.75	[illegible]
July 6	W. E. Hall	80	132	.46	1.80	[illegible]
September 23	do	75	124	.40	1.74	[illegible]
September 23	do	75	124	.38	1.72	[illegible]
October 5	J. M. Giles	80	111	.38	1.69	[illegible]
October 5	do	40	36	1.41	1.70	[illegible]

MUCKALEE CREEK NEAR ALBANY, GA.

This station was established as a temporary station March 9, 1903, by F. A. Murray. It is located at the wagon bridge 3 miles north of Albany, Ga., and a short distance below the mouth of Kinchafoonee Creek. The gage is a vertical rod of 1 by 4 inch board nailed to a scantling, fastened to a tree on the left bank just above the bridge, and reads from zero to 14 feet. During 1903 it was read once each day by T. M. Nelson. Discharge measurements are made from the single-span highway bridge and its approaches. The initial point for soundings is the river side of the iron pier on the right bank, downstream side of the bridge. The channel is straight for 300 feet above the station and for 200 feet below. The current is regular and of

moderate velocity. Both banks are high and will not overflow. The bed is rocky and probably permanent. The river flows in one channel at all stages. Backwater from Flint River affects the discharge at high stages.

Bench mark No. 1 is the top of the upstream pier on the right bank; its elevation is 27.65 feet above the zero of the gage. Bench mark No. 2 is a copper plug set in a rock on the right bank about 40 feet below the bridge. Its elevation is 11.91 feet above the zero of the gage. The station was discontinued December 31, 1903, but has been maintained as a bench-mark station during 1904.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Muckalee Creek near Albany, Ga., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
March 6	F. A. Murray		992	5.18	6.60	5,141
May 22	M. R. Hall		1,005	2.81	7.40	2,829
July 2	F. A. Murray		582	2.53	1.88	1,473
September 19	do		907	4.62	6.22	4,195
October 15	M. R. Hall		364	1.76	.72	644
December 22	F. A. Murray		462	2.90	1 59	1,343
1904.						
April 22	W. E. Hall	80	443	2.37	1.45	1,051
June 18	B. S. Drane	80	350	1.20	.33	419
September 22	J. M. Giles	76	338	1.35	.35	455
November 16	B. S. Drane	90	391	2.13	.95	832

KINCHAFOONEE CREEK NEAR ALBANY, GA.

This station was established as a temporary station March 9, 1903, by F. A. Murray. It is located at the wagon bridge 3 miles north of Albany, Ga., 200 feet below the Central of Georgia Railroad bridge and about one-half mile above the mouth of the creek. The gage is a vertical rod fastened to the cypress tree on the left bank 100 feet above the bridge, and reads from zero to 10 feet. During 1903 it was read once daily by T. M. Nelson. Discharge measurements are made from the single-span highway bridge and its approaches, which cross the river at an angle to the direction of the current. The initial point for soundings is the center of the iron pier on the left bank, downstream side. The channel is curved both above and below the station. Both banks are high and all water passes beneath the bridge and its approaches. The bed is probably somewhat shifting.

Bench mark No. 1 is the top of the crossbeam 30 feet from the initial point for soundings on the upstream side of the bridge. Its elevation is 26.52 feet above the zero of the gage. Bench mark No. 2 is a copper plug set in a rock on the left bank about 25 feet below the bridge. Its elevation is 6.97 feet above the zero of the gage. Bench mark No. 3 is the top of the iron pier on the left bank, upstream side. Its elevation is 26.37 feet above the zero of the gage. The station was discontinued December 31, 1903, but has been maintained as a bench-mark station during 1904.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Kinchafoonee Creek near Albany, Ga., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
March 6	F. A. Murray		973	3.99	4.28	3,88
May 22	M. R. Hall		721	2.33	3.32	1,68
July 2	F. A. Murray		650	1.45	1.84	94
September 19	do		833	2.46	3.29	2,05
October 15	M. R. Hall		581	.73	.98	42
December 22	F. A. Murray		667	1.27	1.76	85
1904.						
June 18	B. S. Drane	88	594	.43	.62	25
September 22	J. M. Giles	66	462	.64	.65	29
November 16	B. S. Drane	89	649	.87	1.12	53

MISCELLANEOUS MEASUREMENTS IN APALACHICOLA RIVER DRAINAGE BASIN

The following is a list of miscellaneous discharge measurements made in Apalachicola River drainage basin during 1904:

Deep Creek near Clarksville, Ga.—This stream is a tributary of Soque River. A measurement was made May 13 from the wooden bridge on Burton road, about 3 miles from Clarksville.

Width, 25 feet; area, 26 square feet; mean velocity, 1.58 feet per second; discharge, 41 second-feet.

Beaverdam Creek near Clarksville, Ga.—This stream is a tributary of Soque River, entering from the right. A measurement was made May 13 from the bridge about 1 mile from Clarksville, on the road to Nacoochee, Ga. The bench mark is the top of the brace from hand-rail to large birch on the upper side of the bridge at the right bank. 12.00 feet above the datum of the gage.

Width, 22 feet; area, 12 square feet; mean velocity, 1.50 feet per second; gage height, 0.45 feet; discharge, 18 second-feet.

Hazel Creek near Demorest, Ga.—This stream is a tributary of Soque River, entering from the left. A measurement was made May 13 from the bridge 1 mile from Demorest, on the road to Porter Mills. The bench mark is the top of the upper end of second floorbeam from the right bank, 15.00 feet above the datum of the gage.

Width, 25 feet; area, 30 square feet; mean velocity, 1.47 feet per second; gage height, 1.85 feet; discharge, 44 second-feet.

Soque River near Clarksville, Ga.—Measurements were made from Wall's bridge, 2½ miles above Clarksville. The bench mark is the top of a nail driven into a large leaning birch tree about 20 feet above the bridge on the left bank, 6.00 feet above the datum of the gage.

March 17: Width, 36 feet; area, 65 square feet; mean velocity, 1.83 feet per second; gage height, 1.35 feet; discharge, 119 second-feet.

March 17: Width, 36 feet; area, 63 square feet; mean velocity, 1.82 feet per second; gage height, 1.35 feet; discharge, 115 second-feet.

May 13: Width, 36 feet; area, 62 square feet; mean velocity, 1.92 feet per second; gage height, 1.45 feet; discharge, 119 second-feet.

Soque River near Cornelia, Ga.—Measurements were made at McHalister's bridge, about 7 miles from Cornelia and 1 mile above the mouth of the river. The bench mark is the top of the downstream end of the first wooden floor beam from the left bank, 22.00 feet above the datum of the gage.

March 18: Width, 74 feet; area, 152 square feet; mean velocity, 1.62 feet per second; gage height, 1.85 feet; discharge, 246 second-feet.

July 16: Width, 72 feet; area, 88 square feet; mean velocity, 1.47 feet per second; gage height, 1.25 feet; discharge, 130 second-feet.

Rottenwood Creek near Vinings, Ga.—This stream enters Chattahoochee River from the right. Measurements were made by wading at a point about 200 feet above the old Thornton dam, and 2 miles above the mouth of the creek. The creek was believed to be at its lowest stage. The bench mark is a nail driven into rock on the right bank at the measuring section, marked "B. M." Its elevation is 3.00 feet above the datum of the gage.

October 4: Width, 9 feet; area, 6 square feet; mean velocity, 0.84 foot per second; gage height, 0.26 foot; discharge, 4.8 second-feet.

October 4: Width, 9 feet; area, 6 square feet; mean velocity, 0.82 foot per second; gage height; 0.26 foot; discharge, 4.9 second-feet.

October 4: Width, 9 feet; area, 6 square feet; mean velocity, 0.72 foot per second; gage height, 0.25 foot; discharge, 4.3 second-feet.

North Fork of Peachtree Creek near Armour, Ga.—A measurement was made May 20, from the Cheshire Bridge, 1½ miles above the Southern Railway bridge at Armour, Ga. The bench mark is the top of a bent nail in the bottom of the twelfth rail post from the right end of the bridge, 16.00 feet above the datum of the gage.

Width, 11 feet; area, 14 square feet; mean velocity, 1.71 feet per second; gage height, 0.90 foot; discharge, 24 second-feet.

Peavine Creek near Armour, Ga.—This stream is the South Fork of Peachtree Creek. A measurement was made May 20, from the wooden bridge on the Cheshire Bridge road, about 1 mile east of Armour, Ga. The bench mark is the top of the head of the upper bolt used to bolt the second rail post from the right end of the bridge to the stringer at the lower side of the bridge. Its elevation is 16.00 feet above the datum of the gage.

Width, 14 feet; area, 13 square feet; mean velocity, 1.23 feet per second; gage height, 0.85 foot; discharge, 16 second-feet.

Peachtree Creek at Armour, Ga.—This stream is a tributary of Chattahoochee River. A measurement was made May 20 from the Southern Railway bridge. The bench mark is the top of the middle stringer at its center on the downstream side of the bridge, 15.00 feet above the datum of the gage.

Width, 27 feet; area, 27 square feet; mean velocity, 1.22 feet per second; gage height, 0.17 foot; discharge, 33 second-feet.

Peachtree Creek near Brookwood, Ga.—Measurements were made at the wagon bridge 1 mile north of Brookwood, on the Peachtree road, and 6 miles north of Atlanta, Ga. The bench mark is the top of the iron plate on the first upright from the right end of the bridge, downstream side, 28.00 feet above the datum of the gage.

May 20: Width, 43 feet; area, 25 square feet; mean velocity, 1.52 feet per second; gage height, 0.68 foot; discharge, 38 second-feet.

April 9: Width, 44 feet; area, 37 square feet; mean velocity, 1.54 feet per second; gage height, 1.12 feet; discharge, 57 second-feet.

Nickajack Creek near Nickajack, Ga.—This stream enters Chattahoochee River from the right, about 1 mile below the old gaging station at Oakdale, Ga. The bench mark is the top of the second upstream iron girder from the left end of the bridge, 12 feet from the end which rests on the center pier, 15.00 feet above the datum of the gage. Measurements were made by wading about 100 feet above the Southern Railway bridge.

October 8: Width, 16 feet; area, 10 square feet; mean velocity, 1.00 foot per second; gage height, 0.92 foot; discharge, 10 second-feet.

October 8: Width, 16 feet; area, 11 square feet; mean velocity, 1.19 feet per second; gage height, 0.94 foot; discharge, 12.6 second-feet.

Sweetwater Creek near Lithia Springs, Ga.—This stream enters Chattahoochee River from the right below the old station at Oakdale, Ga. A measurement was made March 15 at Adair's bridge, 2 miles north of Lithia Springs, and above the regular station on Sweetwater Creek near Austell, Ga. The bench mark is the top of the downstream end of the cap of first wooden bent from the left end of the bridge, 10.00 feet above the datum of the gage.

Width, 66 feet; area, 295 square feet; mean velocity, 1.37 feet per second; gage height, 1.50 feet; discharge, 404 second-feet.

Sweetwater Creek near Austell, Ga.—A measurement was made March 15 at Ferguson's mill bridge 5 miles from Austell. The bench mark is a nail driven into the river side of a birch tree on the right bank 12 feet below the bridge, 5.00 feet above the datum of the gage.

Width, 129 feet; area, 484 square feet; mean velocity, 1.67 feet per second; gage height, 1.50 feet; discharge, 807 second-feet.

Flint River near Montezuma, Ga.—A measurement was made September 21 at the highway bridge, about 1 mile northwest of Montezuma. The bench mark is the top of the upstream pier at the left bank, which was 26.15 feet above the water surface. The gage height given is that taken from the temporary gage belonging to the United States Weather Bureau.

Width, 188 feet; area, 1,300 square feet; mean velocity, 0.75 foot per second; gage height, 10.63 feet; discharge, 971 second-feet.

Flint River near Concord, Ga.—A measurement was made September 24 from the wooden bridge 5 miles from Concord. The bench mark is the top of the first post from the right bank on the downstream side of the bridge, 12.00 feet above the datum of the gage.

Width, 92 feet; area, 184 square feet; mean velocity, 0.43 foot per second; gage height, 2.05 feet; discharge, 79 second-feet.

Flint River near Woodbury, Ga.—Measurements were made at Powell's bridge, 3 miles above the regular gaging station at Woodbury. The bench mark is the top of the right upstream post of first pier from the right bank, 15.00 feet above the datum of the gage.

January 16: Width, 139 feet; area, 527 square feet; mean velocity, 1.39 feet per second; gage height, 5.88 feet; discharge, 730 second-feet.

September 22: Width, 116 feet; area, 332 square feet; mean velocity, 0.43 foot per second; gage height, 4.54 feet; discharge, 144 second-feet.

October 4: Width, 115 feet; area, 314 square feet; mean velocity, 0.34 foot per second; gage height, 4.40 feet; discharge, 107 second-feet.

White Oak Creek near Riverview, Ga.—This stream enters Flint River from the right, about 13 miles above the regular gaging station on Flint River at Woodbury, Ga. A measurement was made March 29 at the double bridges one-half mile from Riverview. The bench mark is the top of the first post, 9.00 feet above the datum of the gage.

Width, 61 feet; area, 222 square feet; mean velocity, 0.50 feet per second; gage height, 2.36 feet; discharge, 112 second-feet.

White Oak Creek near Warnersville, Ga.—A measurement was made March 29 at the wagon bridge one-half mile west of Warnersville. The bench mark is the top of the first post on the downstream side of the bridge, 13.00 feet above the datum of the gage.

Width, 38 feet; area, 163 square feet; mean velocity, 0.71 foot per second; gage height, 1.25 feet; discharge, 115 second-feet.

Red Oak Creek near Woodbury, Ga.—This stream is tributary to Flint River, from the right, 3 miles above the regular gaging station

on Flint River at Woodbury. The bench mark is the top of the first post from the right-bank edge, downstream side, 15 feet from a large white oak tree. Its elevation is 20.00 feet above the datum of the gage. Measurements have been made from the wagon bridge on the road to Concord, about 4 miles from Woodbury, 1 mile above the mouth of the creek, as follows:

January 16: Width, 68 feet; area, 134 square feet; mean velocity, 1.24 feet per second; gage height, 4.12 feet; discharge, 166 second-feet.

October 4: Width, 18 feet; area, 27 square feet; mean velocity, 0.68 foot per second; gage height, 2.65 feet; discharge, 18 second-feet.

Big Potato Creek near Thomaston, Ga.—Before the section now adopted as a regular bench-mark station was found, two measurements of Big Potato Creek were made at the covered wagon bridge, 2½ miles from Thomaston, just below the Macon and Birmingham Railroad trestle. The bench mark is the top of the downstream lower stringer at sounding point 80. The elevation above gage zero is 15.00 feet.

January 15: Width, 82 feet; area, 188 square feet; mean velocity, 0.85 feet per second; gage height, 3.30 feet; discharge, 160 second-feet.

March 31: Width, 72; area, 175 square feet; mean velocity, 0.74 feet per second; gage height, 3.25 feet; discharge, 130 second-feet.

Blue Spring near Albany, Ga.—This spring is of considerable local note. It is about one-half mile from the left bank of Flint River, and about 4 miles below Albany, Ga. Measurements were made from the foot log over the outlet of the main spring as follows:

April 19: Width, 25 feet; area, 45 square feet; mean velocity, 3.00 feet per second gage height, 3.29 feet; discharge, 135 second-feet.

September 23: Width, 28 feet; area, 30 square feet; mean velocity, 1.47 feet per second; gage height, 2.85 feet; discharge, 44 second-feet.

November 16: Width, 22 feet; area, 21 square feet; mean velocity, 1.24 feet per second; gage height, 2.77 feet; discharge, 26.4 second-feet.

CHOCTAWHATCHEE DRAINAGE BASIN.

Choctawhatchee River drains the southeastern part of Alabama, and that portion of Florida lying immediately south. The main river rises in Barbour County, Ala., a short distance west of Eufaula, Ala., and flows in a southwesterly and southerly direction through the Choctawhatchee Bay to the Gulf of Mexico. Pea River is the principal tributary and enters from the west at Geneva, Ala. This branch is the longer of the two, measured above their junction, having its head in Bullock County near Union Springs, Ala. Double Bridges Creek is an important but small tributary lying between the main branches, and entering Choctawhatchee River just above the mouth of Pea River. These are all moderately swift streams, even at low water, and at places the fall is sufficient to make considerable shoals or rapids, and offer practicable sites for water-power developments. During 1904 the

United States Geological Survey established and maintained gaging stations on Choctawhatchee River near Geneva, Ala.; on Pea River at Pera, Ala., and on Double Bridges Creek at Geneva, Ala.

CHOCTAWHATCHEE RIVER NEAR GENEVA, ALA.

This station was established August 26, 1904, by M. R. Hall. It is located at a wagon bridge about 1 mile from Geneva and one-fourth mile from Eunola, Ala. The gage is an 8-foot vertical scale, graduated to feet and tenths, reading from 1 to 9 feet, and continued on the 2 by 6 inch scantling to which it is attached. This scantling is fastened to the upstream side of a heavy pile, which was a part of the right bent of the old bridge which occupied the same site as the new one. This pile is the second from the downstream end of a line of 5 set up and down stream. The gage is read once each day by James McGowan. Discharge measurements are made from the downstream side of the three-span iron drawbridge, having about 50 feet of trestle approach on either end. The initial point for soundings is the left end of the iron bridge on the downstream side. The channel is straight for 200 feet above and for one-half mile below the bridge. The current has a fair velocity. The right bank is a sand bluff about 27 feet high. There are a few trees on the face of the bluff and the top is wooded. The left bank is an overhanging rock cliff to a height of about 10 feet, above which it is sandy and slopes gradually to a total height of about 27 feet. Both banks are subject to overflow. The bed of the stream is composed of firm sand for the greater part, there being some rock at the left bank, and is clean and permanent. There is one channel at all but very high stages, when both banks overflow, and a second channel is formed by lower ground some distance from river on the right bank. The station is about three-fourths mile above the mouth of Double Bridges Creek and is also near the junction with Pea River. Backwater from both of these streams will affect the gage heights during times of unequal rise, and the station is maintained only temporarily for low-water measurements. Bench mark No. 1 is the top of the downstream end of the fourth floor beam from the right end of the bridge, this being the first beam from the left end of the span. Its elevation is 32.00 feet above the zero of the gage. Bench mark No. 2 is a large wire nail in the river side of a cypress tree on the right bank, about 140 feet below the bridge. Its elevation is 12.07 feet above the zero of the gage.

The station was discontinued on December 31, 1904.

Discharge measurements of Choctawhatchee River near Geneva, Ala., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
May 27	M. R. Hall	111	418	1.54	2.07	642
June 21	B. S. Drane	117	369	1.26	1.63	464
August 26	M. R. Hall	120	801	1.34	4.18	1,073
September 26	J. M. Giles	102	322	1.50	1.38	483
September 26	do	102	313	1.47	1.36	461
November 18	B. S. Drane	118	395	1.62	1.81	643
November 18	do	118	397	1.60	1.81	635

Mean daily gage height, in feet, of Choctawhatchee River near Geneva, Ala., for 1904.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1		3.50	1.40	1.25	1.85	17		1.70	1.15	1.85	2.70
2		3.30	1.50	1.40	2.40	18		1.70	1.20	1.90	2.90
3		2.85	1.30	2.05	6.10	19		1.65	1.30	1.75	2.80
4		2.45	1.25	2.40	5.50	20		1.65	1.25	1.80	2.70
5		2.50	1.30	2.10	4.95	21		1.60	1.25	1.70	2.70
6		2.75	1.30	1.80	6.65	22		1.50	1.30	1.85	2.70
7		2.80	1.45	1.75	5.75	23		1.50	1.25	2.40	2.50
8		3.20	1.55	1.70	4.45	24		1.60	1.10	2.30	2.50
9		2.90	1.45	1.75	3.85	25		1.55	1.10	2.10	2.50
10		2.60	1.30	1.60	3.50	26	4.20	1.40	1.25	2.00	2.50
11		2.45	1.30	1.65	3.40	27	4.30	1.45	1.30	1.90	4.40
12		2.10	1.30	1.50	3.20	28	5.80	1.50	1.30	1.75	6.80
13		2.00	1.35	1.95	2.90	29	6.20	1.45	1.30	1.80	5.50
14		1.90	1.30	2.20	2.85	30	4.50	1.45	1.30	1.80	5.40
15		1.80	1.25	1.95	2.80	31	3.90		1.25		5.40
16		1.80	1.25	1.90	2.50						

DOUBLE BRIDGES CREEK AT GENEVA, ALA.

This station was established August 26, 1904, by M. R. Hall. It is located at the wagon bridge on the outskirts of Geneva, Ala., about three-fourths mile above the mouth of the creek. The gage is a vertical scale 9 feet long graduated to feet and tenths bolted to a 2-inch by 6-inch scantling which is spiked to the upstream side of a cypress tree on the left bank about 100 feet below the bridge. It is read once each day by James McGowan. Discharge measurements are made from the upstream side of the single span, iron bridge to which the gage is attached. The initial point for soundings is the upstream side of the left end of the iron bridge. The channel is curved for about 200 feet above, and straight for about 600 feet below the station. The current has a good velocity. Both banks are about 15 or 17 feet high, wooded except at bridge, and are subject to overflow. The bed of

the stream is composed of sand, and is clean except near the right bank where a half buried tree forms an obstruction. There is but one channel at all stages.

During high water the gage heights are affected by back water from Choctawhatchee River, and the station is maintained only temporarily for low-water measurements. Bench mark No. 1 is the bottom of the upstream end of the first floor beam from the left end of the bridge. Its elevation is 19.80 feet above the zero of the gage. Bench mark No. 2 is a chisel cut and white paint mark on the intermediate post 6 feet above bench mark No. 1. Its elevation is 25.80 feet above the zero of the gage.

Discharge measurements of Double Bridges Creek at Geneva, Ala., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
May 27	M. R. Hall	45	90	1.38	1.61	124
June 21	B. S. Drane	45	81	1.22	1.24	99
August 26	M. R. Hall	62	244	2.59	4.63	633
September 26	J. M. Giles	47	78	1.08	1.45	84
September 26	do	47	94	1.22	1.82	115
November 18	B. S. Drane	49	83	1.22	1.52	101
November 18	do	49	94	1.22	1.60	115

Mean daily gage height, in feet, of Double Bridges Creek at Geneva, Ala., for 1904.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.10	1.35	1.45	1.40	17	.....	1.40	.90	1.60	2.35
2	.....	2.50	1.25	1.80	3.35	18	.....	1.65	1.10	1.70	2.60
3	.....	2.20	1.00	2.70	5.90	19	.....	1.75	1.20	1.40	2.30
4	.....	2.10	1.00	2.70	4.80	20	.....	1.30	1.05	1.60	2.00
5	.....	2.10	1.30	2.10	5.25	21	.....	1.30	.85	1.60	1.95
6	.....	2.40	1.05	1.70	5.40	22	.....	1.20	.90	1.70	2.05
7	.....	2.50	1.45	1.65	4.30	23	.....	1.55	1.10	2.45	1.90
8	.....	2.85	1.70	1.40	2.95	24	.....	1.35	.90	2.80	2.10
9	.....	1.85	1.05	1.30	2.50	25	.....	1.45	1.00	1.90	1.90
10	.....	1.90	1.15	1.15	2.75	26	.....	1.25	.90	1.45	2.05
11	.....	1.80	1.15	1.40	2.60	27	4.90	1.40	1.05	1.75	2.05
12	.....	1.60	1.05	1.45	2.50	28	5.50	1.30	1.10	1.15	4.80
13	.....	1.40	1.15	2.40	2.00	29	4.60	1.30	1.30	1.70	4.80
14	.....	1.50	1.10	2.05	2.10	30	3.00	1.35	1.40	1.60	3.30
15	.....	1.30	.85	1.75	2.15	31	3.00	.....	1.10	.....	2.60
16	.....	1.40	1.10	1.60	2.05						

PEA RIVER AT PERA, ALA.

This station was established August 27, 1904, by M. R. Hall. It is located at the Elton wagon bridge, about one-half mile west of Pera,

Ala., a station on the Georgiana and Graceville Branch of the Louisville and Nashville Railroad. A chain gage is fastened to the top plank of the upstream fencing of the bridge, with the pulley end of the box abutted against the intermediate post over the second floor beam from the right bank. The scale is attached to the top of the plank. The length of the chain from the end of the weight to the marker is 48.20 feet. The gage is read once each day by W. G. Early, who is paid by the Alabama Geological Survey. Discharge measurements are made from the downstream side of the single-span bridge to which the gage is attached. The initial point for soundings is the outside of the downstream tubular iron pier at the right bank. The channel curves to the left about 150 feet above the station, which tends to throw the greatest current velocity along the right bank, and is straight below the station for about 1,000 feet. The current has a fair velocity. The right bank is composed of rock, vertical for about 20 feet from low-water level, and is free from vegetation. The left bank is composed of sand and mud, rising gradually. It is wooded above and below, but cleared at the bridge. Both banks are subject to overflow during extreme high water. The bed of the stream is composed of smooth rock toward the right bank and sand toward the left. There is one channel at all stages. Bench mark No. 1 is the top of the downstream end of the first floor beam from the right pier. Its elevation is 42.00 feet above gage datum. Bench mark No. 2 is a chisel mark on the intermediate post at downstream end of the first floor beam from right bank, 5 feet above bench mark No. 1. Its elevation is 47.00 feet above the datum of the gage. Bench mark No. 3 is the top of the upstream end of the second floor beam from the right bank. Its elevation is 42.03 feet above the datum of the gage. Bench mark No. 4 is a chisel mark on the post 4.97 feet above bench mark No. 3. Its elevation is 47.00 feet above gage datum.

Discharge measurements of Pea River at Pera, Ala., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge
		Feet.	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
May 26	M. R. Hall	68	319	0.89	2.47	285
June 22	B. S. Drane	67	263	.74	1.80	194
August 27	M. R. Hall	81	446	1.77	4.66	790
September 27	J. M. Giles	64	161	1.18	1.59	190
September 27	do	64	157	1.20	1.60	189
November 17	B. S. Drane	70	204	1.50	2.32	307
November 17	do	70	206	1.49	2.34	308

Mean daily gage height, in feet, of Pea River at Pera, Ala., for 1904.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	5.3	1.6	1.8	2.2	17	.....	2.3	1.3	2.2	3.3
2	.....	4.5	1.4	1.4	3.2	18	.....	2.1	1.3	2.2	3.4
3	.....	3.9	1.4	2.0	5.3	19	.....	1.9	1.4	2.1	3.5
4	.....	3.3	1.4	2.2	4.4	20	.....	1.5	1.4	2.2	3.4
5	.....	3.5	1.4	2.1	6.1	21	.....	1.6	1.4	2.1	3.3
6	.....	3.6	1.4	2.2	7.6	22	.....	1.8	1.4	2.3	3.3
7	.....	4.6	2.1	2.1	6.1	23	.....	1.5	1.3	2.6	3.2
8	.....	4.8	1.7	2.0	5.4	24	.....	1.4	1.2	2.4	3.1
9	.....	3.7	1.6	2.0	5.0	25	.....	1.6	1.2	2.4	3.0
10	.....	3.4	1.5	1.9	4.5	26	.....	1.5	1.3	2.4	3.2
11	.....	3.0	1.6	2.0	4.2	27	4.7	1.6	1.4	2.3	4.9
12	.....	2.8	1.6	1.8	4.0	28	6.9	1.6	1.3	2.3	7.6
13	.....	2.6	1.5	2.2	3.7	29	7.5	1.6	1.4	2.3	8.0
14	.....	2.4	1.5	2.3	3.6	30	7.1	1.6	1.4	2.2	7.0
15	.....	2.2	1.4	2.4	3.4	31	6.2	.....	1.4	.....	6.5
16	.....	2.3	1.5	2.3	3.3						

ESCAMBIA RIVER DRAINAGE BASIN.

Escambia River drains the south-central portion of Alabama and empties into the Gulf of Mexico through Escambia Bay and Pensacola Bay. Conecuh River joins the Escambia about 5 miles south of the Alabama-Florida State line, and is very much the larger of the two branches. Conecuh River rises in Bullock County, Ala., very close to the headwaters of Pea River in the Choctawhatchee drainage, and flows southwesterly throughout its course. Pigeon and Patsaliga creeks, both from the west, are the principal tributaries of Conecuh River. The Conecuh and its tributaries are swift streams and at places there are rocky shoals or rapids. During 1904 the United States Geological Survey established and maintained a gaging station on Conecuh River at Beck, near Andalusia, Ala.

CONECUH RIVER AT BECK, ALA.

This station was established August 24, 1904, by M. R. Hall. It is located at Simmons Bridge at Beck, Ala., and about 12 miles below the mouth of Patsaliga Creek. The nearest railway station is Andalusia, Ala., 8 miles east, on the Central of Georgia and Louisville and Nashville railways. A chain gage is fastened to the channel-iron fencing post which is riveted to the upstream end of the first floor beam of the main span, 72 feet from the initial point for soundings. The gage box and scale are bolted to a 2-inch by 6-inch scantling, which is bolted horizontally to this post and the main end post. The length of the chain from the end of the weight to the marker is 53.50 feet. The gage is read once each day by W. R. Duggan, who is paid by the Ala-

bama Geological Survey. Discharge measurements are made from the upstream side of the iron bridge to which the gage is attached. The bridge consists of a main span 125 feet long with a 50-foot span at each end. The approach on the right bank is 50 feet of wooden and 90 feet of iron trestle; on the left bank, 20 feet of wooden trestle. The initial point for soundings is the end of the iron bridge at the left bank on the upstream side. The channel is straight for 600 feet above and for about one-half mile below the station. The current is fairly swift. Both banks are steep. The right bank is composed of rock to a height of about 8 feet, then earth covered with bushes to a total height of about 30 feet, and is subject to overflow. The left bank is composed of rock to a height of from 15 to 20 feet, then earth covered with bushes to a total height of about 35 feet, and overflows only at extreme high water. The bed of the stream is composed of fine sand, there being some smooth rock along the left bank. There are some sunken logs in the section which obstruct the current to some extent. There is one channel at all stages. Bench mark No. 1 is the top of the upstream end of the first iron floor beam of the main span from the left pier. Its elevation is 47.50 feet above gage datum. Bench mark No. 2 is the top of the iron channel-bar post to which the gage is fastened. Its elevation is 52.17 feet above the zero of the gage.

Discharge measurements of Conecuh River at Beck, Ala., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
May 26	M. R. Hall	110	274	1.17	1.67	320
June 24	B. S. Drane	109	231	1.03	1.18	238
August 24	M. R. Hall	115	392	1.50	2.63	588
September 28	J. M. Giles	108	232	1.06	1.20	245
September 28	do	108	237	1.03	1.20	244
November 19	B. S. Drane	111	245	1.19	1.40	292
November 19	do	111	245	1.18	1.40	290

Mean daily gage height, in feet, of Conecuh River at Beck, Ala., for 1904.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.50	1.10	0.80	1.50	17	.....	1.30	0.85	1.40	2.20
2	.....	2.80	1.00	.90	2.30	18	.....	1.40	.90	1.40	2.20
3	.....	2.90	1.00	1.45	2.60	19	.....	1.20	.95	1.40	2.10
4	.....	5.35	.70	1.40	2.65	20	.....	1.20	.95	1.35	2.00
5	.....	4.10	.80	1.25	4.00	21	.....	1.00	.80	1.35	2.00
6	.....	3.40	.85	1.25	3.70	22	.....	1.40	.80	1.70	1.80
7	.....	2.90	1.30	1.30	3.35	23	.....	1.30	.80	1.85	1.75
8	.....	2.30	1.00	1.35	3.30	24	3.60	1.20	.85	1.50	1.75
9	.....	2.20	1.00	1.35	3.00	25	4.70	1.20	.90	1.80	1.80
10	.....	2.20	1.05	1.30	2.90	26	3.10	1.00	.90	1.85	1.85
11	.....	2.00	.85	1.30	2.80	27	2.90	1.00	.90	1.70	1.95
12	.....	1.70	1.00	1.15	2.50	28	5.70	1.05	.90	1.70	4.40
13	.....	1.80	.95	1.35	2.40	29	4.50	1.05	.90	1.60	3.50
14	.....	1.60	.95	1.40	2.35	30	4.00	1.10	.85	1.60	3.60
15	.....	1.60	.80	1.20	2.20	31	3.50	.....	.85	.....	3.50
16	.....	1.50	.80	1.20	2.20						

MOBILE RIVER DRAINAGE BASIN.

This is the largest drainage basin in Georgia and Alabama, and is designated the Mobile basin because its waters all enter the Gulf through Mobile River at Mobile, Ala. It is formed as follows: Beginning at the headwaters, Cartecay and Ellijay rivers unite at Ellijay, Ga., to form Coosawattee River. Just above Resaca, Ga., this unites with the Conasauga to form Oostanaula River. At Rome, Ga., the Oostanaula and the Etowah unite to form Coosa River. Six miles above Montgomery, Ala., the Coosa and the Tallapoosa unite to form Alabama River; and not far from the coast the Tombigbee unites with the Alabama to form Mobile River, which flows into Mobile Bay, an arm of the Gulf of Mexico.

Cahaba River is the principal tributary of the Alabama and joins it about 10 miles below Selma. Hillabee Creek flows into Tallapoosa River just above Sturdevant and near Alexander. Talladega Creek is a tributary of the Coosa.

Tombigbee River rises in the northeastern part of Mississippi and enters Alabama in Pickens County. Its principal tributary is the Black Warrior, which is formed by the junction of Mulberry Fork and Sipsey Fork. Locust Fork enters the Black Warrior some distance below the junction.

The following pages give the results of the data collected in this drainage during 1904:

ALABAMA RIVER AT SELMA, ALA.

This station, which was originally established by the United States Engineer Corps, is now maintained by the United States Weather

Bureau. The station is at the iron highway bridge one block from Water street, Selma, Ala. The gage is in two sections. The first section, reading from − 3 to + 5.1 feet, is fastened to the lower side of the cofferdam on the second pier; the upper section, reading from 5.1 to 55 feet, is bolted to the draw pier. Discharge measurements are made from the bridge and the trestle approach on the left bank. The initial point for soundings is the end of the drawbridge on the right bank, upstream side. The channel above the station is slightly curved for 1,000 feet and straight for 2,000 feet below the station. The velocity is good and the current is regular. The right bank is high and rocky and will not overflow. The left bank is high, but overflows at extreme high water. The bed is mostly soft blue rock, and the water is confined to one channel. Bench mark No. 1 is an iron bolt driven into the rock bluff 182 feet from the first pier on the road leading up from the boat landing; its elevation is 26.00 feet above the zero of the gage and 88 feet above mean sea level. Bench mark No. 2 is the top of the capstone of the pivot pier. Its elevation is 56.00 feet above the zero of the gage. Bench mark No. 3 is the edge of the coping on the right bank abutment, just under the downstream side of the drawbridge; its elevation is 59.51 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Alabama River at Selma, Ala., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
April 10 [a]	J. M. Giles	497	12,600	4.69	22.35	59,100
June 19 [a]	do	401	5,461	3.44	6.45	18,820
November 11 [a]	do	258	3,298	2.51	1.00	8,290
1904.						
January 22 [b]	J. M. Giles	397	4,864	3.33	5.20	16,200
January 23 [b]	do	402	5,059	3.37	5.55	17,050
April 8 [b]	do	386	4,746	2.74	4.20	13,010
August 5 [b]	do	391	5,131	2.85	4.60	14,600
August 5 [b]	do	391	5,100	2.74	4.30	13,970
November 1 [a]	do	235	2,473	1.08	−2.20	2,665
November 1 [a]	do	235	2,492	1.12	−2.20	2,786

[a] Wagon bridge. [b] Measured at Louisville and Nashville Railroad bridge.

Mean daily gage height, in feet, of Alabama River at Selma, Ala., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.6	4.7	8.3	7.4	2.0	0.0	0.5	1.5	2.9	−1.3	−1.8	−0.9
2	1.1	4.0	7.0	6.5	2.1	1.3	3.9	2.0	2.0	−1.4	−1.8	− .9
3	1.0	3.8	6.1	5.7	2.1	2.8	2.8	3.6	1.6	−1.4	−1.8	− .9
4	1.0	3.8	5.7	5.1	2.0	3.0	2.6	4.5	1.2	−1.4	−1.6	− .8
5	1.0	3.6	5.5	4.6	1.9	2.8	2.6	4.8	1.2	−1.5	−1.6	− .6
6	.9	3.5	5.4	4.2	1.6	2.6	1.9	3.5	.9	−1.6	−1.6	− .1
7	.9	4.0	5.4	4.0	1.4	2.7	2.0	4.8	.6	−1.6	−1.6	.4
8	1.0	6.8	6.1	4.2	1.2	2.3	1.7	8.7	.3	−1.7	−1.6	.7
9	1.0	11.0	9.7	5.1	1.2	2.0	1.5	16.4	.3	−1.8	−1.8	2.0
10	1.9	15.6	11.0	6.5	1.2	2.2	.8	22.5	.4	−1.8	−1.8	3.4
11	2.6	19.6	10.8	7.4	1.1	2.2	1.3	22.9	.3	−1.8	−1.6	4.0
12	3.9	21.0	10.0	7.0	1.1	1.4	1.3	20.3	.2	−1.8	−1.6	4.5
13	5.2	21.5	9.0	7.2	1.1	.8	1.3	17.5	− .2	−1.8	−1.4	4.5
14	4.0	19.9	7.9	7.2	.8	.7	.9	15.6	− .4	−1.8	−1.4	4.0
15	3.6	17.0	7.0	6.4	1.4	.5	1.7	11.0	− .8	−1.8	−1.4	3.0
16	2.7	13.0	7.3	5.2	1.6	.2	2.0	9.1	− .9	−1.8	−1.4	2.5
17	2.8	9.9	9.4	4.1	1.6	.0	.8	7.5	− .9	−1.8	−1.4	2.0
18	3.7	7.6	11.0	3.8	1.4	− .3	.5	6.6	−1.0	−1.8	−1.4	1.5
19	4.1	6.1	11.3	3.1	1.0	− .3	− .1	5.8	−1.0	−1.8	−1.4	1.0
20	5.1	5.7	10.1	2.9	1.0	− .4	− .3	5.2	−1.2	−1.8	−1.4	1.0
21	4.5	6.0	8.9	2.8	.8	− .5	− .1	4.0	−1.2	−1.8	−1.4	.5
22	4.7	7.0	7.5	2.5	.5	− .6	.0	3.5	−1.3	−1.8	−1.4	.5
23	5.6	8.3	6.5	2.3	.5	−1.1	.1	2.7	−1.3	−1.8	−1.2	− .5
24	10.9	10.0	5.7	2.1	.2	−1.1	.6	2.0	−1.3	−1.8	−1.0	−1.4
25	12.9	11.8	5.1	2.1	.0	−1.1	.8	1.8	−1.4	−1.8	− .6	−1.6
26	12.0	12.0	5.8	2.0	.0	−1.1	.8	2.5	−1.4	−1.8	− .6	−1.6
27	10.9	12.6	8.0	1.9	− .2	−1.0	.7	3.0	− .9	−1.8	− .6	−1.6
28	9.7	10.8	9.4	1.9	− .4	− .6	.5	4.0	− .4	−1.8	− .6	.0
29	8.1	9.7	9.7	1.9	− .5	− .3	.4	3.7	− .7	−1.8	− .8	1.0
30	6.6	.....	9.2	1.9	− .5	− .3	.8	4.0	−1.2	−1.8	− .9	6.4
31	5.4	.....	8.3	.....	− .2	.....	.9	3.8	.....	−1.8	.....	6.7

Rating table for Alabama River at Selma, Ala., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
− 2.20	2,700	−0.80	4,820	1.00	7,800	7.50	20,700
−2.10	2,850	− .70	4,980	1.50	8,700	8.00	21,800
−2.00	3,000	− .60	5,140	2.00	9,600	8.50	22,900
−1.90	3,150	− .50	5,300	2.50	10,550	9.00	24,000
−1.80	3,300	− .40	5,460	3.00	11,500	10.00	26,300
−1.70	3,450	− .30	5,620	3.50	12,450	11.00	28,600
−1.60	3,600	− .20	5,780	4.00	13,400	12.00	31,000
−1.50	3,750	− .10	5,940	4.50	14,400	13.00	33,450
−1.40	3,900	0.00	6,100	5.00	15,400	14.00	36,000
−1.30	4,050	.20	6,440	5.50	16,450	15.00	38,600
−1.20	4,200	.40	6,780	6.00	17,500	16.00	41,300
−1.10	4,350	.60	7,120	6.50	18,550	17.00	44,000
−1.00	4,500	.80	7,460	7.00	19,600	18.00	46,700
− .90	4,660						

The preceding table is fairly well defined to gage height 3.4 feet. The table has been extended beyond this limit. It is based upon discharge measurements made during 1900–1904. Above gage height 18 feet the rating curve is a tangent, the difference being 275 per tenth.

Estimated monthly discharge of Alabama River at Selma, Ala., for 1904.

[Drainage area, 15,400 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	33,200	7,630	14,830	0.963	1.11
February	56,320	12,450	27,160	1.76	1.90
March	29,320	15,610	21,890	1.42	1.64
April	20,480	9,420	14,130	.918	1.02
May	9,790	5,300	7,726	.502	.57
June	11,500	4,350	7,259	.471	.52
July	13,210	5,620	8,088	.525	.60
August	60,180	8,700	21,510	1.40	1.61
September	11,310	3,900	5,865	.381	.42
October	4,050	3,300	3,421	.222	.25
November	5,140	3,300	3,981	.258	.28
December	18,970	3,600	8,467	.550	.63
The year	60,180	3,300	12,030	.781	10.59

ETOWAH RIVER AT CANTON, GA.

This station was established in 1892 by the United States Weather Bureau. Measurements were begun in 1896 by the United States Geological Survey. It is located at the wagon bridge in Canton, Ga., one-half mile above the mouth of Canton Creek and 1,000 feet upstream from the Atlanta, Knoxville and Northern Railway station. The gage is a heavy vertical timber, bolted to the edge of the left-bank pier, on the upstream side. The foot marks are numbered with brass figures. The gage is read once each day by J. M. McAfee, who is paid by the United States Weather Bureau for six months of the year and by the Georgia Geological Survey for the other six months. Discharge measurements are made from the upstream side of the iron highway bridge, which is about 25 feet above low water, and to which the gage is attached. The initial point for soundings is the river side of the right-bank pier at the end of the main span. The channel is straight for 1,000 feet above and 500 feet below the bridge. The current is affected by a fish-trap dam about 1 foot high, which was constructed in 1902, and which has since caused some trouble by being occasionally washed away and built

up again. Up to 3 feet gage height the river is only 116 feet wide and flows between the piers on its lower banks. Up to about 14 feet it is confined between its upper banks, which are the abutments at the outer end of the approaches. Above this point it begins to overflow the bottom lands. The bed is fairly constant.

Bench mark No. 1 is a cut on a silver maple tree on the east side of the road, 20 feet from the end of the bridge on the south or left bank of the river; its elevation is 20.36 feet above the zero of the gage. Bench mark No. 2 is a cut on a persimmon tree 4 feet from the upper side of the bridge and 10 feet toward the river from the south end of the bridge; its elevation is 16.88 feet above the zero of the gage. Bench mark No. 3 is the center of the head of a large wire nail, driven horizontally in the side (toward the river) of a walnut tree on the east side of the road, 25 feet north of the north end of the bridge; its elevation is 18.52 feet above the zero of the gage. Bench mark No. 4 is the top of the iron bar on the top of the left-bank pier at the end of the center span of the bridge; its elevation is 23.39 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Etowah River at Canton, Ga., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
January 28	M. R. Hall		568	1.62	1.07	922
March 27	O. P. Hall		765	3.35	2.50	2,562
April 27	E. C. Murphy		669	2.80	1.80	1,873
June 25	M. R. Hall		563	2.07	.94	1,166
June 25	do		563	1.99	.93	1,119
September 4	do		520	1.10	.51	570
September 4	do		523	1.10	.51	575
October 10	do		525	.98	.60	513
1904.						
January 15	M. R. Hall	114	531	1.02	.50	542
March 3	O. P. Hall	113	529	1.55	.78	821
May 17	do	108	460	1.08	.18	497
July 26	M. R. Hall	105	437	.75	.04	328
July 26	do	105	438	.74	.04	324
September 1	O. P. Hall	109	437	.86	.06	374
October 8	M. R. Hall	105	398	.50	— .38	197
October 8	do	105	414	.55	— .25	227
October 13	O. P. Hall	107	385	.45	— .38	171

Mean daily gage height, in feet, of Etowah River at Canton, Ga., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	De.
1	0.4	0.6	0.7	0.6	0.5	1.3	0.5	0.5	0.1	−0.4	0.0	
2	.4	.6	.7	.6	.4	.6	.4	1.2	.1	− .4	.1	
3	.4	.6	.9	.6	.3	.3	.3	1.2	.1	− .3	.2	
4	.4	.6	.7	.4	.3	.1	.2	.5	.3	− .3	.3	
5	.4	.6	.7	.4	.3	.0	.6	2.5	.3	− .4	.4	
6	.4	.6	.7	.4	.2	.0	.4	.8	.3	− .3	.3	
7	.5	.7	2.1	.7	.2	.5	.2	.4	.1	− .3	.2	
8	.5	1.6	1.7	1.0	.8	.2	.3	8.0	.0	− .3	.2	
9	.5	1.0	.9	.9	1.1	.0	.1	4.0	.0	− .4	.2	
10	.5	.6	.8	.8	.6	− .1	.0	1.0	.0	− .4	.2	
11	.6	.6	.8	.7	.3	− .1	.0	.8	− .1	− .3	.2	
12	.6	.6	.8	.7	.3	− .1	.2	1.1	− .1	− .3	.2	
13	.6	.7	.8	.6	.3	− .1	.8	.8	− .2	− .4	.4	
14	.6	.7	2.0	.5	.3	− .1	.3	.5	− .1	− .3	.6	
15	.5	.7	1.2	.5	.3	− .2	.1	.4	− .2	− .4	.4	
16	.5	.7	.8	.5	.2	− .2	.0	.3	− .3	− .3	.3	
17	1.1	.7	.8	.5	.2	− .2	.5	.3	− .3	− .3	.3	
18	.9	.6	.7	.5	.2	− .2	.2	.2	− .3	− .3	.3	
19	.7	.8	.7	.5	.2	− .3	.4	.1	− .3	− .3	.3	
20	.6	2.5	.6	.5	.1	− .3	.0	.2	− .3	− .3	.3	
21	.5	1.2	.6	.5	.1	.2	.0	.2	− .3	− .3	.3	
22	.7	2.6	1.2	.6	.0	.1	− .1	.0	− .3	− .2	.4	
23	1.7	1.0	.6	.5	.0	− .2	.1	.1	− .3	− .1	.7	
24	1.0	1.0	.6	.4	.0	− .3	.1	.7	− .4	− .2	.5	
25	.7	.8	.8	.4	.0	.1	.0	.5	− .4	− .1	.4	
26	.7	.8	.8	.5	− .1	.0	.1	.3	− .4	.0	.3	
27	.7	.7	.8	.5	− .1	− .1	− .1	.4	− .4	.0	.3	
28	.7	.6	.7	.5	− .2	.1	.0	.3	− .2	.0	.3	
29	.8	.6	.7	.5	− .3	.6	.0	.1	− .2	.0	.3	
30	.7	.....	.7	.5	− .3	3.8	.0	.1	− .3	.0	.3	
31	.6	.....	.6	.....	1.3	.....	.0	.0	.....	.0	.....	

Rating table for Etowah River at Canton, Ga., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
−0.50	170	−0.10	280	0.30	470	0.70	755
− .40	190	.00	320	.40	532	.80	840
− .30	215	.10	365	.50	600	.90	930
− .20	245	.20	415	.60	675	1.00	1,020

The above table is based upon discharge measurements made during 1902 to 1904. It is well defined between gage heights −0.5 foot and 1 foot. Estimates above 1-foot gage height are based on a tangent, the difference being 90 per tenth.

Estimated monthly discharge of Etowah River at Canton, Ga., for 1904.

[Drainage area, 604 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	1,650	532	720	1.19	1.37
February	2,460	675	916	1.52	1.64
March	2,010	675	914	1.51	1.74
April	1,020	532	650	1.08	1.20
May	1,290	215	469	.776	.895
June	3,540	215	479	.793	.885
July	840	280	418	.692	.798
August	7,320	320	979	1.62	1.87
September	470	190	278	.460	.513
October	320	190	236	.391	.451
November	755	320	480	.795	.887
December	2,370	532	724	1.20	1.38
The year	7,320	190	605	1.00	13.63

ETOWAH RIVER NEAR ROME, GA.

This station was established August 17, 1904, by M. R. Hall. It is located at Freeman's ferry, about 5 miles above Rome, Ga. The gage is in three sections. The first section is the original gage, reading from zero to 7 feet, securely attached to a sycamore tree at left edge of river, about 250 feet below the ferry. The second section, reading from 7 to 20 feet, is attached to a chestnut post located 10 feet upstream from the first section and 10 feet from the edge of the river (low water); post about 10 inches in diameter and 21 feet long, the bottom of the post extending to firm gravel, 1.50 feet below low-water surface. The hole is filled with stone and about one-third concrete, the concrete being at the bottom and near the surface of ground, 7 feet above the bottom of the post. The third section, reading from 20 to 30 feet, is attached to a maple tree opposite post, and 15 feet farther from the water's edge. Each section of the gage is of 1¼ by 2½ inch heart pine, well painted, and graduated by V-shaped grooves, which are painted black. The gage is made up in 5-foot lengths, all of which are securely fastened to substantial supports. The gage is read once each day by Frank B. Freeman, who is paid by the Georgia Geological Survey. Discharge measurements are made from a small boat, the meter being suspended from the ferry cable. Measurements can be

made from the bridge at Rome, as no large quantity of water enters the river between the ferry and that place. Gage heights may be obtained at Rome by telephoning the observer. The initial point for soundings is the center of the windlass for the ferry cable on the left bank of the river. The channel is straight for about 3,000 feet above and for 1,000 feet below the station. The current is swift. There is a small shoal of rock about 50 feet below the gaging section. About 1,000 feet below there is an old fish-trap dam, but this has not been used for years and is probably constant. Both banks are high, but are subject to overflow during high water. The bed of the stream is composed of small rock and pebbles, and is uniform and permanent. There is but one channel at all stages, the water being about 2.5 feet deep at low water.

Bench mark No. 1 is head of lag screw driven in root of maple to which gage 20 to 30 feet is attached; elevation is 19.26 above datum. Bench mark No. 2 is head of nail driven in root at base of maple tree, 100 feet up river from gage; elevation, 22.18 feet. Bench mark No. 3 is center mark on copper plug set horizontally in brick wall of F. B. Freeman's residence, on east end of house, near northeast corner, just below floor level; elevation, 27.99 feet above datum.

Discharge measurements of Etowah River near Rome, Ga., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
August 18[a]	M. R. Hall	156	752	1.40	2.00	1,049
August 18[b]	do	295	748	1.42	2.03	1,064
September 27[b]	W. E. Hall	290	552	.85	1.37	470
October 15[b]	do	285	510	.78	1.26	397
November 8[b]	do	291	588	.98	1.50	574

[a] At Rome, Second Avenue Bridge.
[b] At Freeman's ferry, 5 miles above Rome.

Mean daily gage height, in feet, of Etowah River near Rome, Ga., for 1904.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	1.75	1.30	1.30	1.55	17	2.10	1.40	1.30	1.60	1.70
2	.....	1.75	1.30	1.30	1.55	18	2.05	1.40	a1.30	1.55	1.75
3	.....	1.70	1.25	1.50	1.60	19	2.10	1.40	1.25	1.55	1.70
4	.....	1.70	1.35	1.40	1.70	20	1.85	1.40	1.35	1.55	1.70
5	.....	1.75	1.30	1.50	1.80	21	1.80	1.40	1.30	1.55	1.65
6	.....	1.80	1.30	1.60	3.10	22	2.50	1.40	1.30	1.55	1.60
7	.....	1.70	1.30	1.55	3.00	23	1.70	1.40	1.30	1.60	1.60
8	.....	1.65	1.30	1.55	2.20	24	3.40	1.40	1.20	1.90	1.60
9	.....	1.60	1.25	1.55	1.90	25	a3.00	1.35	1.25	1.75	1.60
10	.....	a1.60	1.20	1.55	1.80	26	2.10	1.35	1.30	1.60	1.70
11	.....	1.60	1.35	1.40	1.90	27	a2.50	1.35	1.30	1.60	1.70
12	.....	1.60	1.35	1.40	1.95	28	2.80	1.35	1.30	1.55	3.00
13	.....	1.50	1.40	a1.50	1.80	29	2.30	1.35	1.30	1.55	3.40
14	.....	1.50	1.30	1.60	1.70	30	1.90	1.35	1.30	1.55	2.50
15	.....	1.50	1.30	1.75	1.70	31	1.90	.....	1.30	.....	2.00
16	.....	1.45	1.30	1.60	1.65						

a Interpolated (no record).

Rating table for Etowah River near Rome, Ga., from August 17 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.20	360	1.80	830	2.40	1,500	3.00	2,320
1.30	425	1.90	930	2.50	1,625	3.10	2,470
1.40	495	2.00	1,035	2.60	1,755	3.20	2,625
1.50	570	2.10	1,145	2.70	1,890	3.30	2,785
1.60	650	2.20	1,260	2.80	2,030	3.40	2,950
1.70	735	2.30	1,380	2.90	2,175		

The above table is based upon 5 discharge measurements made during 1904 and 1 made February, 1905. It is well defined.

Estimated monthly discharge of Etowah River near Rome, Ga., for 1904.

[Drainage area, 1,854 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
August (17–31)	2,950	735	1,384	0.746	0.416
September	.830	460	588	.317	.354
October	495	360	423	.228	.263
November	930	425	614	.331	.369
December	2,950	610	1,027	.554	.639

COOSA RIVER AT RIVERSIDE, ALA.

This station was established September 25, 1896, by M. R. Hall. It is located at the Southern Railway bridge, Riverside, Ala., about 4 miles below Lock No. 4. The 24-inch boxed chain gage is fastened to the downstream guard rail at a point 570 feet from the initial point for soundings. The length of the chain from the marker to the end of the weight is 35.02 feet. The gage is read once each day by S. T. Waits. Discharge measurements are made from the railway bridge to which the gage is attached. The initial point for soundings is the water face of the abutment on the left bank, downstream side. Distances are marked on the guard rail with white paint. The channel is straight above the station for about 400 feet and below for about 3,000 feet. The current is swift, but is broken by a ledge of rock 300 feet above the bridge. The channel is 614 feet between bridge abutments and is broken by four piers. The width at ordinary stages is about 575 feet. Both banks are high; the left bank is liable to overflow, but all water passes beneath the bridge. The bed of the stream is rocky and permanent and not very rough.

Bench mark No. 1 is the capstone on the circular pier of the turn span, the elevation of which is 26.80 feet above gage datum. Bench mark No. 2 is a copper plug set in solid rock on the right bank, about 100 feet above the bridge. Its elevation is 11.95 feet above gage datum. The observer is paid by the Alabama Geological Survey.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Coosa River at Riverside, Ala., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Sec. feet.*
March 16	J. M. Giles	570	8,977	4.46	10.75	40,070
April 11	do	566	7,680	4.00	8.80	30,710
June 20	do	500	4,120	1.79	2.87	7,374
July 22	do	492	3,871	1.43	2.30	5,549
August 26	do	429	3,234	1.24	1.64	4,001
October 1	do	405	2,865	.94	1.05	2,687
November 13	do	430	3,113	1.01	1.37	3,136
1904.						
January 19	J. M. Giles	446	3,444	1.16	1.88	3,999
February 11	M. R. and W. E. Hall.	528	4,785	2.27	4.10	10,880
May 26	J. M. Giles	409	2,895	.94	1.25	2,714
June 27	do	407	2,861	.90	1.15	2,582
August 23	do	497	3,268	.97	1.45	3,174
September 20	A. T. Mitchelson.	488	2,947	.57	.60	1,681
September 21	do	485	2,783	.56	.53	1,557
November 2	J. M. Giles	433	2,625	.48	.38	1,250

Mean daily gage height, in feet, of Coosa River at Riverside, Ala., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.35	2.10	2.90	4.00	2.30	2.30	2.60	1.15	1.20	0.50	0.35	0.70
2	1.30	2.05	2.60	3.60	2.15	2.70	2.55	1.35	1.20	.50	.40	.80
3	1.30	2.05	2.45	3.40	2.10	2.80	2.30	1.50	1.20	.50	.45	.80
4	1.25	2.00	2.60	3.10	1.90	3.00	2.15	2.60	1.10	.50	.60	1.00
5	1.25	2.00	2.85	3.00	1.90	2.55	1.90	2.80	1.00	.50	.65	1.70
6	1.20	1.90	3.05	2.75	1.80	2.05	1.45	3.00	1.00	.55	.70	2.75
7	1.20	1.95	3.90	2.70	1.75	1.70	2.10	3.80	1.00	.60	.75	3.20
8	1.20	2.75	4.30	3.20	1.80	1.65	2.15	4.20	1.00	.60	.75	3.75
9	1.20	3.35	4.80	3.80	1.90	1.65	1.55	3.80	1.00	.55	.75	3.50
10	1.20	3.55	5.20	5.10	1.80	1.95	1.40	4.35	1.00	.50	.70	3.20
11	1.25	4.05	4.80	5.20	1.80	2.00	1.40	6.25	.95	.50	.70	3.00
12	1.30	3.95	4.30	4.90	2.60	1.70	1.40	5.40	.95	.50	.70	2.85
13	1.30	3.70	4.30	4.20	2.20	1.50	1.40	4.15	.85	.50	.65	2.60
14	1.30	3.35	4.30	3.50	2.10	1.30	1.25	3.20	.80	.45	.55	2.40
15	1.40	3.05	4.05	3.00	2.00	1.15	1.25	2.70	.70	.40	.55	2.00
16	1.45	2.90	4.00	2.80	1.70	1.15	1.25	2.55	.60	.40	.60	1.60
17	1.50	2.30	3.90	2.70	1.60	1.05	1.30	2.30	.60	.40	.70	1.30
18	1.80	2.35	3.70	2.60	1.50	1.05	1.30	2.15	.60	.40	.70	1.25
19	1.90	2.50	3.80	2.40	1.55	1.05	1.40	1.95	.60	.40	.65	1.20
20	2.10	2.90	3.80	2.40	1.50	1.00	1.65	1.75	.60	.35	.65	1.10
21	2.25	3.25	3.50	2.35	1.40	1.00	1.50	1.65	.75	.35	.65	1.10
22	2.50	3.80	3.20	2.25	1.35	1.00	1.30	1.50	.90	.35	.70	1.10
23	4.45	4.90	3.30	2.20	1.30	1.00	1.10	1.45	.90	.35	.75	1.10
24	5.10	5.45	5.30	2.20	1.30	1.40	1.10	1.35	.90	.35	.75	1.10
25	5.00	6.05	6.10	2.15	1.20	1.50	1.10	1.30	.75	.35	.75	1.10
26	4.30	5.80	6.85	2.15	1.20	1.40	1.15	1.25	.60	.35	.75	1.10
27	4.00	4.80	6.20	2.15	1.15	1.20	1.20	1.25	.60	.35	.75	1.70
28	3.70	3.80	5.90	2.40	1.15	1.00	1.20	2.00	.55	.35	.80	2.90
29	3.30	3.30	5.50	2.50	1.20	1.50	1.20	1.90	.55	.35	.80	3.75
30	2.55	.....	4.90	2.60	1.20	2.25	1.10	1.55	.55	.35	.80	5.00
31	2.30	.....	4.40	.....	1.80	.....	1.15	1.40	.....	.35	.....	5.20

Rating table for Coosa River at Riverside, Ala., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
.30	1,150	1.40	3,010	2.40	5,425	3.80	9,780
.40	1,300	1.50	3,215	2.50	5,695	4.00	10,480
.50	1,450	1.60	3,430	2.60	5,970	4.20	11,200
.60	1,605	1.70	3,655	2.70	6,250	4.40	11,920
.70	1,760	1.80	3,890	2.80	6,540	4.60	12,640
.80	1,920	1.90	4,130	2.90	6,835	4.80	13,360
.90	2,085	2.00	4,380	3.00	7,135	5.00	14,080
1.00	2,255	2.10	4,635	3.20	7,750	5.50	15,900
1.10	2,435	2.20	4,895	3.40	8,400	6.00	17,750
1.20	2,620	2.30	5,160	3.60	9,080	6.50	19,600
1.30	2,810						

The preceding table is based upon seven discharge measurements made during 1904 and several older measurements. It is well defined between gage heights 0.4 feet and 4 feet. The table has been extended beyond these limits.

Estimated monthly discharge of Coosa River at Riverside, Ala., for 1904.

[Drainage area, 7,065 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches
January	14,440	2,620	5,228	0.740	0.853
February	17,940	4,130	8,391	1.19	1.28
March	20,900	5,560	11,370	1.61	1.86
April	14,800	4,765	7,462	1.06	1.18
May	5,970	2,527	3,676	.520	.600
June	7,135	2,255	3,598	.509	.568
July	5,970	2,435	3,314	.469	.541
August	18,680	2,527	6,118	.866	.988
September	2,620	1,528	1,987	.281	.314
October	1,605	1,225	1,351	.192	.221
November	1,920	1,225	1,713	.242	.270
December	14,800	1,760	5,127	.726	.837
The year	20,900	1,225	4,945	.700	9.52

OOSTANAULA RIVER AT RESACA, GA.

This station was maintained by the United States Geological Survey from August 1, 1896, to April 30, 1899. During this time it was also maintained by the United States Weather Bureau as a half-year station. The gage height records are now taken for the Weather Bureau during the entire year by their local observer, G. A. Norton. The station is located at the bridge of the Western and Atlantic Railway, which is in the town of Resaca, 800 feet south of the depot. A heavy timber gage is attached vertically to the downstream side of the center pier. Discharge measurements are made from the downstream side of the iron through bridge to which the gage is attached. The bridge consists of three spans of 120 feet each, and 480 feet of trestle approach at the left bank. The left bank span of the bridge is entirely outside of the river, except at high water. Measurements are also made from a boat at the ferry about 200 feet above the bridge, where the section is somewhat better. The initial point for soundings is the end of the bridge at the right bank, downstream side. The channel is slightly curved, the same curve extending about 300 feet above and below the bridge. The current is moderate, becoming rather sluggish at low water. The right bank is rock at the edge of water, and has solid stone abutment and railroad embankment, which is above high-water level. The left bank

is low, cultivated, and overflows during high water 480 feet to the end of the trestle. The bed of the stream is composed of rock near the right bank, but other parts appear to be sandy. To the left of the pier it is nearly filled up with logs and brush. There is one channel broken by one pier at ordinary water. Bench mark No. 1 is the top of the downstream end of the second crossbeam from the right bank. Its elevation is 28.94 feet above the datum of the gage. Bench mark No. 2, established March 14, 1905, is a cross mark on the top of the limestone bowlder on the north side of the river, about 130 feet from the end of the railroad bridge and 40 feet west of the railroad track. Its elevation is 34.23 feet above the datum of the gage.

COOSAWATTEE RIVER AT CARTERS, GA.

This river is formed by the junction of Ellijay and Cartecay rivers at Ellijay, Ga., and flows in a southwesterly direction, joining the Conasauga to form the Oostanaula. Its drainage area is for the most part mountainous and covered with forest growth. This station was established August 15, 1896, by M. R. Hall, at the iron highway bridge at Carters, Murray County, Ga., about 20 miles northeast of Calhoun, the most convenient railroad station. Carters is at the head of navigation, small boats running to Rome, Ga., and the Coosa River below. It is at the foot of the great shoals made by this stream in cutting through the Cohutta Mountains.

A standard chain gage is attached to the downstream side of the bridge in the third panel from the right bank. The original length of the chain before it was boxed was 37.08 feet from the end of the weight to the marker. On March 17, 1905, the gage was replaced by a boxed gage of the 24-inch iron top type, and the length of the chain was made 36.57 feet from the end of the weight to the marker, the datum remaining the same. The observer is R. P. Messer, a merchant at Carters, Ga., who is paid by the Georgia Geological Survey.

Discharge measurements are made from the single-span highway bridge and its approaches. The initial point for soundings is land side of the pier on the right bank. The channel is curved for 1,000 feet above and 500 feet below the station. The current is swift and broken. Both banks are high, but overflow at flood stages. The bed of the stream is of gravel, and is not liable to change.

Bench mark No. 1 is the top of the cylindrical iron pier at the right bank, downstream side. Its elevation is 30.35 feet above gage datum. Bench mark No. 2, established March 17, 1905, is a stone post set into the ground on the north side of the river about 300 feet from the end of the iron bridge and on the west side of the road leading toward Carter's mill. The elevation of the top of the post is 22.15 feet above the datum of the gage.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Coosawattee River at Carters, Ga., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
March 18	O. P. Hall		518	3.06	3.56	1,58[illegible]
July 22	do		380	2.53	2.35	963
September 8	do		265	1.67	1.22	444
September 8	M. R. Hall		265	1.72	1.22	456
October 16	O. P. Hall		242	1.55	1.07	374
December 31	do		247	1.68	1.26	416
1904.						
March 15	O. P. Hall	118	418	2.50	2.60	1,045
May 26	do	107	252	1.70	1.30	427
June 25	do	107	220	1.46	.99	322
August 23	do	104	203	1.54	.85	312
September 27	do	83	181	1.12	.50	202
December 21	do	102	191	1.44	.82	275
December 21	M. R. Hall	100	186	1.26	.73	235

Mean daily gage height, in feet, of Coosawattee River at Carters, Ga., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.20	1.50	1.70	2.20	1.70	2.00	1.10	5.00	0.80	0.50	0.40	2.00
2	1.10	1.50	1.70	2.20	1.70	1.80	1.00	2.00	.70	.50	.40	2.20
3	1.40	1.50	1.70	2.10	1.70	1.50	1.00	1.50	.70	.50	.40	1.80
4	1.10	1.50	3.50	2.00	2.00	1.30	1.00	1.30	.70	.45	.70	1.60
5	1.10	1.40	3.75	1.90	1.80	1.20	1.00	1.60	.90	.45	.60	1.80
6	1.10	1.30	3.00	1.90	1.70	3.10	1.40	1.20	.80	.45	.60	1.60
7	1.10	1.40	3.00	1.90	1.70	3.00	1.30	1.10	.70	.45	.50	1.40
8	1.10	2.80	2.50	4.00	4.45	2.00	1.80	1.60	.70	.45	.50	1.30
9	1.10	2.60	2.20	3.00	3.00	1.80	1.50	2.00	.60	.40	.50	1.20
10	1.10	1.80	2.10	2.50	2.00	1.60	1.20	1.50	.60	.40	.50	1.10
11	1.30	1.60	2.00	2.30	1.80	1.30	1.00	1.40	.60	.40	.40	1.00
12	1.30	1.50	1.90	2.20	1.70	1.30	2.05	1.30	.60	.40	.40	1.00
13	1.30	1.50	1.80	2.00	1.70	1.20	1.70	1.10	.50	.40	.40	1.00
14	1.30	1.40	4.80	1.90	1.70	1.20	1.20	1.00	.50	.40	.40	.90
15	1.20	1.70	2.80	1.90	1.60	1.20	1.00	1.00	.70	.40	.40	.90
16	1.30	1.70	2.20	1.90	1.60	1.20	1.00	1.00	.60	.40	.40	.90
17	2.80	1.60	2.10	1.80	1.60	1.10	1.80	1.00	.60	.40	.40	.85
18	1.90	1.60	2.00	1.80	1.60	1.10	1.30	1.00	.50	.40	.40	.85
19	1.50	3.40	1.80	1.80	1.50	1.10	1.00	.90	.50	.40	.40	.85
20	1.40	3.00	1.80	1.80	1.50	1.00	1.00	.90	.40	.40	.40	.85
21	1.40	2.30	1.80	1.80	1.50	3.00	.90	.90	.40	.40	.40	.85
22	4.35	4.80	2.00	1.80	1.50	2.00	1.80	.80	.40	.40	.50	.85
23	3.00	3.50	5.20	1.80	1.40	1.50	1.50	.80	.50	.40	.60	.80
24	2.30	2.40	3.80	1.70	1.40	1.20	1.00	.80	.50	.40	.60	.80
25	2.00	2.20	2.90	1.70	1.30	1.00	1.00	.90	.50	.40	.60	1.00
26	1.70	2.10	2.80	4.00	1.30	1.00	1.00	1.00	.45	.40	.60	1.30
27	1.60	2.00	2.80	2.50	1.30	1.00	.90	.90	.50	.40	.60	3.90
28	1.50	1.80	2.60	2.00	1.20	1.20	1.10	1.00	.50	.40	.50	4.00
29	1.50	1.80	2.50	1.80	1.20	1.20	1.00	.90	.50	.40	.50	2.00
30	1.50	.....	2.40	1.70	1.20	1.80	1.00	.90	.50	.40	1.80	1.80
31	1.50	.....	2.30	.....	3.70	.....	.90	.80	.....	.40	.....	1.80

Rating table for Coosawattee River at Carters, Ga., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.40	184	1.80	650	4.20	2,000	9.50	5,790
.50	202	1.90	698	4.40	2,130	10.00	6,150
.60	222	2.00	747	4.60	2,270	11.00	6,870
.70	244	2.20	848	4.80	2,410	12.00	7,590
.80	269	2.40	952	5.00	2,550	13.00	8,310
.90	296	2.60	1,058	5.50	2,910	14.00	9,030
1.00	326	2.80	1,166	6.00	3,270	15.00	9,750
1.10	358	3.00	1,275	6.50	3,630	16.00	10,470
1.20	393	3.20	1,385	7.00	3,990	17.00	11,190
1.30	430	3.40	1,500	7.50	4,350	18.00	11,910
1.40	470	3.60	1,620	8.00	4,710	19.00	12,630
1.50	512	3.80	1,740	8.50	5,070	20.00	13,350
1.60	557	4.00	1,870	9.00	5,430	21.00	14,070
1.70	603						

The above table is based upon seventeen discharge measurements made during 1902, 1903, and 1904. It is well defined between gage heights 0.5 foot and 4.5 feet. The table has been extended beyond these limits to gage height 5.5. Above gage height 4.8 feet the rating curve is a tangent, the difference being 73 per tenth.

Estimated monthly discharge of Coosawattee River at Carters, Ga., for 1904.

[Drainage area, 531 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	2,097	358	575	1.08	1.24
February	2,410	430	791	1.49	1.61
March	2,694	603	1,063	2.00	2.31
April	1,870	603	823	1.55	1.73
May	2,165	393	659	1.24	1.43
June	1,330	326	549	1.03	1.15
July	772	296	408	.768	.885
August	2,550	269	453	.853	.983
September	296	184	220	.414	.462
October	202	184	187	.352	.406
November	650	184	215	.405	.452
December	1,870	269	524	.987	1.14
The year	2,694	184	539	1.01	13.80

CARTECAY RIVER NEAR CARTECAY, GA.

This station was established June 27, 1904, by M. R. Hall. It is located at the Cartecay Bridge on the public road 6 miles southeast (upstream) from Ellijay, Ga., and 1½ miles northwest from Cartecay, Ga. Turkey Creek enters from the south side and Owltown Creek from the north side between this point and Ellijay. There is probably no considerable interference from dams above the station. The gage is a vertical 10-foot timber, graduated to feet and tenths, fastened to a 2-inch by 4-inch oak scantling, which is spiked to the sill and downstream post of trestle bent at the right bank. The gage is read once each day by S. A. Burrell, who is paid by the Georgia Geological Survey. Discharge measurements are made from the downstream side of the single 60-foot span wooden bridge to which the gage is attached. The bridge has an approach on the right bank of 24 feet and on the left bank of 26 feet. The floor is about 16 feet above low water. The initial point for soundings is the edge of the abutment on the right bank, downstream side. The channel is straight for about 500 feet above and below the station. The current is swift. Both banks are high, but are subject to overflow. The bed of the stream is composed of rock and is permanent, the water flowing in one channel. The bench mark is the top of the downstream end of the first floor beam from the right bank, marked by nails and white paint. Its elevation is 16.50 feet above the zero of the gage.

Discharge measurements of Cartecay River near Cartecay, Ga., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
May 9	O. P. Hall	55	78	2.26	1.30	176
June 27	do	53	50	1.72	.90	86
August 31	do	53	50	1.88	.85	94
October 12	do	48	38	1.84	.65	70
December 13	M. R. Hall	52	46	1.70	.80	78

Mean daily gage height, in feet, of Cartecay River near Cartecay, Ga., for 1904.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.10	1.10	0.80	0.90	0.75	1.15	17	1.80	1.30	1.80	0.70	0.75	0.90
2	1.10	1.20	.85	(a)	.80	.90	18	1.50	1.25	2.10	.70	.80	.85
3	1.80	2.40	1.20	(a)	.80	1.10	19	3.05	3.55	.90	.75	.85	.80
4	1.50	1.65	1.10	(a)	.85	1.00	20	3.05	2.15	.90	.60	.90	.75
5	1.70	2.30	.90	(a)	.90	1.50	21	2.20	1.90	.85	.65	.80	.75
6	1.75	2.85	.90	(a)	.80	1.20	22	1.70	1.70	.80	.75	.95	.70
7	3.30	1.90	.85	(a)	.85	1.20	23	1.60	1.30	2.30	.75	.95	.70
8	2.20	1.70	.80	(a)	.90	1.10	24	2.20	1.25	2.15	.75	.90	.90
9	1.40	1.50	1.40	(a)	.95	1.00	25	1.95	3.35	.95	.65	.85	1.10
10	1.80	1.45	.85	(a)	.90	1.00	26	1.30	2.70	1.90	.60	.80	.90
11	1.35	1.40	.80	(a)	1.20	.90	27	1.25	1.60	.80	.65	.80	.90
12	3.50	2.65	.80	.65	1.30	.90	28	1.70	1.15	.80	.70	.85	2.50
13	5.40	2.10	.85	(a)	1.10	.80	29	1.25	1.10	1.20	.75	.85	2.20
14	2.30	1.70	.80	(a)	.95	.80	30	1.10	.90	.90	.70	1.30	1.20
15	2.10	1.50	.75	(a)	.90	.85	31	.....	.85	.....	.70	.....	.90
16	1.30	1.35	.80	(a)	.80	.85							

a Missing.

ELLIJAY RIVER NEAR ELLIJAY, GA.

This station was established June 28, 1904, by M. R. Hall for the purpose of making a series of miscellaneous measurements. It is located at a wagon bridge about one-half mile east of Ellijay, Ga., and about the same distance above the junction of Ellijay and Cartecay rivers. A section of gage staff, graduated by feet and tenths from 2 to 6 feet, is nailed to the downstream vertical post at the right bank, and a bench mark established for reference. Regular gage readings are not maintained. Discharge measurements are made from the open wooden wagon bridge, having two 40-foot spans and 50-foot approaches on each bank. The initial point for soundings is the end of the bridge at right bank, on the downstream side. Both banks are straight for about 500 feet above and below the station. The right bank is about 12 feet high and the left bank is about 10 feet high. Both banks are bordered by fields and are subject to overflow. There is one channel broken by one wooden pier. The bed of the stream is composed of rock, partly sloping, and the current ranges from very swift above the station to sluggish below. The bench mark is a small nail and white paint mark in downstream vertical post at right bank. Its elevation is 7.00 feet above the gage datum.

Discharge measurements of Ellijay River near Ellijay, Ga., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet*
December 9....	O. P. Hall.....	65	56	1.36	.....	76
1904.						
May 10.....	O. P. Hall.....	74	90	1.71	1.80	154
June 28.....	.....do	66	61	1.54	1.35	94
August 30.....	.....do	68	56	1.22	1.22	68
October 12.....	.....do	56	41	1.03	1.07	42
December 14...	M. R. Hall.....	66	50	1.32	1.20	66

MOUNTAINTOWN CREEK NEAR ELLIJAY, GA.

This station was established as a bench-mark station May 10, 1904, by O. P. Hall. It is located at the covered bridge known as Charles Bridge, about 4 miles west of Ellijay, Ga., and about the same distance above the mouth of the creek. The bridge consists of a single span of 54 feet, with short trestle approaches at either end. Discharge measurements are made from the bridge, the meter being lowered through holes in the floor, or from a foot log a half mile below the bridge. The initial point for soundings is the end of the trestle approach at the right bank. The channel is straight for about 500 feet above and 100 feet below the station and the current is swift. Both banks are high and not liable to overflow. The bed of the stream is rocky. The water is shallow and swift at the bridge, the better section being at the foot log below the bridge. The bench mark is a nail driven into the vertical post of the main bent under the right end of the bridge, 6 feet above the top of the mud sill of the bent. Its elevation is 7.00 feet above datum.

Discharge measurements of Mountaintown Creek near Ellijay, Ga., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet*
May 10.....	O. P. Hall.....	60	51	3.08	1.17	157
August 31.....	.....do	52	34	2.32	.85	79
October 12.....	.....do	26	44	.70	.75	31

TALKING ROCK CREEK NEAR CARTERS, GA.

This station was established as a bench-mark station May 26, 1904, by O. P. Hall, though numerous measurements of the creek have pre-

viously been made by M. R. Hall and O. P. Hall in connection with measurements of the Coosawattee River station. It is located about 3 miles above the mouth of Talking Rock Creek and about the same distance east of Carters, Ga. Discharge measurements are made from a boat just above R. L. Hill's boat landing or by wading at a shoal a short distance below. Both banks are high and will probably not overflow. There is one channel at all stages. The section is a good one. The bench mark is a nail in a large elm tree on the left bank at R. L. Hill's boat landing. Its elevation is 7.50 feet above datum.

Discharge measurements of Talking Rock Creek near Carters, Ga., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
May 26	O. P. Hall	59	103	0.48	1.24	49
June 25	do	58	97	.35	1.08	34
August 23	do	22	18	2.22	1.07	40

CHOCCOLOCCO CREEK NEAR JENIFER, ALA.

The gage at this station was established August 20, 1902, by J. M. Giles. Measurements were first made by J. R. Hall in 1900. It is located at the Louisville and Nashville Railroad bridge, 1¼ miles north of Jenifer, Ala. There are small shoals both above and below the bridge. The gage consists of a vertical 1 by 4 inch pine plank, nailed to a 3 by 8 inch pine timber which is spiked to a birch tree 20 feet upstream from the bridge on the left bank. It reads from 0.30 to 10 feet. The observer is W. J. Tolbert, who is paid by the Alabama Geological Survey. Discharge measurements are made from the single-span bridge and its trestle approach on the right bank. The initial point for soundings is the end of the bridge on the left bank, and distances are marked with white paint on the upstream guard rail. The channel is straight for 1,500 feet above and below the station and has a width between abutments of 145 feet and 100 feet at low water. The right bank overflows at a gage reading of about 6 feet. The left bank is high and will not overflow except under the bridge. The bed is rocky and not likely to change.

Bench mark No. 1 is the top of a crossbeam at a point 50 feet from the initial point for soundings. Its elevation is 23.00 feet above the zero of the gage. Bench mark No. 2 is a copper plug in the upstream wing of the left abutment; its elevation is 14.19 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Choccolocco Creek near Jenifer, Ala., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet*
July 23.....	J. M. Giles	96	158	1.17	2.25	18[illegible]
July 23.....	.....do	96	157	1.14	2.25	1[illegible]
August 20.....	.....do	98	158	1.16	2.26	18[illegible]
August 25.....	.....do	99	174	.84	2.12	14[illegible]
October 2.....	.....do	85	115	.78	1.82	9[illegible]
November 14..	.....do	96	125	1.04	2.08	13[illegible]
1904.						
January 20....	J. M. Giles	95	144	.97	2.09	13[illegible]
February 12...	W. E. Hall	105	228	1.71	2.82	39[illegible]
February 12...	M. R. Hall	105	219	1.75	2.85	38[illegible]
February 20...	Murphy and Giles	100	220	1.74	2.72	38[illegible]
March 10	W. E. Hall	100	183	1.29	2.40	23[illegible]
May 27.....	J. M. Giles	85	115	.72	1.80	8[illegible]
July 20.....	W. E. Hall	85	128	.94	1.99	12[illegible]
August 24.....	J. M. Giles	90	134	.92	1.94	12[illegible]
August 30.....	.....do	90	135	.92	1.95	12[illegible]
September 22 .	A. T. Michelson.	90	116	.79	1.71	9[illegible]
October 12....	J. M. Giles	86	128	.81	1.83	10[illegible]
October 12....	.....do	86	127	.78	1.80	9[illegible]
November 26..	.....do	86	128	.73	1.75	9[illegible]
November 26..	.....do	86	129	.79	1.86	10[illegible]

Mean daily gage height, in feet, of Choccolocco Creek near Jenifer, Ala., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.90	2.10	2.30	2.10	2.10	2.20	2.10	1.90	1.80	1.65	1.40	1.50
2	1.90	2.10	2.30	2.10	2.00	2.20	2.00	2.00	1.80	1.70	1.40	1.60
3	1.90	2.10	2.30	2.15	2.00	2.10	2.20	2.00	1.80	1.70	1.60	1.70
4	2.00	2.10	2.20	2.10	2.00	1.90	1.90	2.00	1.80	1.60	1.70	1.70
5	1.90	2.10	2.20	2.10	2.00	1.85	1.80	2.80	2.10	1.60	1.70	1.80
6	1.90	2.10	2.20	2.15	2.00	1.85	1.80	2.20	2.00	1.60	1.80	2.00
7	1.90	2.30	2.60	2.10	2.00	1.80	1.80	3.50	1.90	1.60	1.70	2.20
8	1.90	3.30	2.60	2.60	2.00	1.80	1.80	3.60	1.80	1.50	1.70	1.90
9	1.90	3.40	2.50	2.80	2.15	1.90	1.90	3.40	1.75	1.60	1.65	1.85
10	1.90	2.80	2.40	2.50	2.15	1.80	2.00	2.70	1.75	1.50	1.60	1.80
11	1.90	2.90	2.30	2.40	2.00	1.80	2.10	2.70	1.80	1.50	1.50	1.80
12	2.00	2.80	2.30	2.30	1.90	1.80	1.90	4.00	1.80	1.50	1.40	1.80
13	2.00	2.60	2.30	2.20	1.90	1.80	1.80	3.00	1.80	1.50	1.70	1.80
14	2.00	2.50	3.00	2.20	1.90	1.80	1.80	2.50	1.70	1.50	1.70	1.70
15	1.90	2.40	3.00	2.20	2.00	1.75	1.80	2.30	1.70	1.50	1.60	1.70
16	1.90	2.30	2.85	2.10	1.90	1.75	1.80	2.40	1.70	1.50	1.60	1.70
17	2.20	2.30	2.60	2.10	1.80	1.75	1.80	2.20	1.65	1.60	1.60	1.70
18	2.30	2.20	2.50	2.10	1.80	1.70	1.80	2.20	1.70	1.50	1.60	1.90
19	2.20	2.20	2.40	2.10	1.80	1.70	1.70	2.00	1.70	1.50	1.60	1.75
20	2.00	2.60	2.35	2.10	1.80	1.70	2.00	2.00	1.65	1.50	1.60	1.70
21	1.90	2.80	2.30	2.10	1.80	1.75	1.80	1.95	1.70	1.50	1.70	1.60
22	2.40	2.80	2.30	2.10	1.80	1.80	1.75	1.95	1.65	1.50	1.70	1.60
23	3.40	3.30	2.30	2.00	1.80	1.75	1.80	1.95	2.10	1.50	1.80	1.60
24	2.80	3.20	2.25	2.00	1.75	1.80	1.75	1.90	2.20	1.40	2.00	1.60
25	2.40	2.80	2.20	2.00	1.80	2.00	1.70	1.90	2.00	1.40	1.80	1.70
26	2.20	2.60	2.20	2.05	1.80	1.90	1.65	1.90	1.80	1.40	1.75	1.80
27	2.10	2.50	2.20	2.20	1.75	1.80	1.70	2.75	1.80	1.40	1.70	1.80
28	2.10	2.50	2.25	2.25	1.80	1.80	1.70	2.10	1.70	1.40	1.70	2.70
29	2.10	2.40	2.20	2.15	1.80	2.50	1.70	2.00	1.70	1.40	1.70	2.60
30	2.10	.....	2.10	2.00	1.80	2.60	2.25	1.95	1.65	1.50	1.60	2.10
31	2.10	.....	2.15	.....	2.00	.....	1.90	1.95	.....	1.50	.....	2.00

Rating table for Choccolocco Creek near Jenifer, Ala., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.40	62	1.90	113	2.40	230	2.80	383
1.50	68	2.00	130	2.50	263	2.90	430
1.60	76	2.10	150	2.60	300	3.00	480
1.70	86	2.20	173	2.70	340	3.10	530
1.80	98	2.30	200				

The above table is based upon twenty discharge measurements made during 1903–4. It is well defined between gage heights 1.70 feet and 2.80 feet. Estimates above 3.1 feet are based upon a tangent with a difference of 55 per tenth.

Estimated monthly discharge of Choccolocco Creek near Jenifer, Ala., for 1904.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
January	695	113	165
February	695	150	307
March	480	150	231
April	383	130	173
May	161	92	116
June	300	86	118
July	186	81	109
August	1,025	113	270
September	173	81	101
October	86	62	70.0
November	130	62	82.7
December	340	68	112
The year	1,025	62	155

TALLADEGA CREEK AT NOTTINGHAM, ALA.

This station was established August 16, 1900, by J. R. Hall. It is located on the Southern Railway bridge, a fourth of a mile from the depot at Nottingham, Ala., and 1 mile north of Alpine, Ala. The gage, which is graduated to feet and tenths and is 20 feet long, is fastened vertically to a tree on the right bank, about 50 feet upstream from the bridge. The observer is R. M. McClatchy, station agent at Nottingham, who is paid by the Alabama Geological Survey.

The initial point for soundings is end of iron bridge, upstream, right bank. The channel is straight for about 500 feet above and below the station and the current is sluggish at low stages. The right bank is high and does not overflow; the left bank is lower than the right and overflows at high stages; but all water passes beneath the bridge. The bed of the stream is of sand and silt and is fairly constant.

Bench mark No. 1 is a nail on the upstream corner of the right bank abutment; its elevation is 14.25 feet above the zero of the gage. Bench mark No. 2 is a copper plug set in the limestone rock at a large spring 335 feet above the railway track on the right bank; its elevation is 6.28 feet above the zero of the gage. The station was discontinued on December 31, 1904.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Talladega Creek at Nottingham, Ala., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
May 25	J. M. Giles		285	0.85	2.05	243
July 27	do		267	.42	1.37	111
August 20	do		254	.46	1.30	116
October 2	do		228	.25	1.00	57
November 14	do		243	.33	1.21	80
1904.						
January 20	J. M. Giles	70	259	.41	1.30	105
January 21	do	70	257	.39	1.27	100
February 20	Giles and Murphy.	70	295	.79	2.02	233
March 10	W. E. Hall	70	264	.55	1.51	145
May 27	J. M. Giles	55	188	.23	1.00	44
May 27[a]	do	27	48	1.04	1.00	50
August 24	do	69	225	.38	1.15	86
September 22	A. T. Michelson	70	222	.32	1.03	72
December 13	J. M. Giles	66	214	.24	1.05	52
December 13[a]	do	32	56	.88	1.05	49

[a] Wagon bridge below mill, one-half mile above railroad bridge.

Mean daily gage height, in feet, of Talladega Creek at Nottingham, Ala., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.10	1.80	1.60	1.30	1.15	1.20	1.70	1.75	1.00	1.00	0.90	1.10
2	1.10	1.60	1.50	1.30	1.10	1.40	1.20	2.45	1.00	1.00	1.00	1.10
3	1.10	1.70	1.50	1.35	1.10	1.20	1.20	1.35	1.00	1.00	1.10	1.10
4	1.10	1.70	1.50	1.35	1.10	1.10	1.10	2.10	1.05	1.00	1.10	1.05
5	1.10	1.60	1.40	1.35	1.10	1.00	1.10	5.60	1.00	1.00	1.10	1.20
6	1.10	1.60	1.40	1.40	1.00	1.00	1.10	3.20	1.00	1.10	1.10	1.20
7	1.10	2.70	2.00	1.40	1.00	1.00	1.05	2.65	1.00	1.10	1.10	1.15
8	1.30	3.80	1.80	1.50	1.10	1.00	1.00	5.70	1.00	1.00	1.05	1.10
9	1.20	2.40	1.65	1.40	1.00	1.00	1.00	4.10	1.00	1.00	1.05	1.10
10	1.50	2.40	1.55	1.35	1.00	1.00	1.10	3.00	1.00	1.00	1.05	1.10
11	1.40	3.20	1.50	1.35	1.00	1.00	1.00	3.10	1.00	1.00	1.05	1.05
12	1.30	2.40	1.50	1.40	1.00	1.00	1.80	2.40	1.00	1.00	1.05	1.05
13	1.30	2.10	1.60	1.35	1.00	1.00	1.80	2.00	1.00	1.00	1.10	1.05
14	1.30	1.80	2.50	1.30	1.00	1.00	1.25	1.70	1.00	1.00	1.20	1.05
15	1.30	1.70	2.20	1.30	1.00	1.00	1.10	1.65	1.00	1.00	1.20	1.05
16	1.30	1.70	1.80	1.30	1.00	.90	1.05	2.10	.95	1.00	1.20	1.05
17	2.50	1.60	1.65	1.30	1.00	.85	1.00	1.55	.95	1.00	1.15	1.10
18	1.80	1.60	1.65	1.30	1.00	.80	1.00	1.40	.95	1.00	1.15	1.00
19	1.60	1.80	1.55	1.30	1.00	1.00	1.00	1.35	.95	1.00	1.10	1.00
20	1.40	2.10	1.50	1.30	1.00	1.00	1.00	1.30	.95	1.00	1.05	1.00
21	1.30	1.80	1.50	1.30	1.00	.90	1.00	1.20	1.00	1.00	1.05	1.00
22	4.00	2.00	1.45	1.30	1.00	.90	1.00	1.15	1.05	1.00	1.20	1.00
23	3.20	2.40	1.40	1.30	1.00	.90	1.00	1.10	1.40	1.00	1.45	1.00
24	2.00	2.10	1.40	1.30	1.00	.85	1.10	1.00	1.20	1.00	1.30	1.00
25	1.70	1.90	1.40	1.25	1.00	.85	1.20	1.00	1.00	.95	1.20	1.20
26	1.50	1.80	1.40	1.25	1.00	1.00	1.10	1.50	1.00	.95	1.15	1.50
27	1.40	1.70	1.40	1.25	1.00	.90	1.05	1.40	1.00	.90	1.10	2.50
28	1.40	1.60	1.40	1.20	1.00	.90	1.10	1.20	1.00	.90	1.10	2.90
29	1.40	1.60	1.35	1.20	1.00	2.15	1.05	1.10	1.00	.90	1.10	1.70
30	1.40	.....	1.35	1.20	1.00	2.20	1.40	1.10	1.00	.90	1.10	1.40
31	1.40	.....	1.35	.....	1.20	.....	1.60	1.00	.....	.90	.....	1.20

Rating table for Talladega Creek at Nottingham, Ala., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.80	20	1.70	172	2.60	374	3.40	588
.90	34	1.80	192	2.70	400	3.50	616
1.00	50	1.90	213	2.80	426	3.60	644
1.10	66	2.00	235	2.90	452	3.70	672
1.20	82	2.10	257	3.00	478	3.80	700
1.30	98	2.20	279	3.10	504	3.90	730
1.40	116	2.30	302	3.20	532	4.00	760
1.50	134	2.40	326	3.30	560	4.10	790
1.60	152	2.50	350				

The above table is poorly defined. It is based upon discharge measurements made during 1903 and 1904. The table has been extended beyond gage height 3 feet.

Estimates of discharges above 4 feet by logarithmic diagram.

Estimated monthly discharge of Talladega Creek at Nottingham, Ala., for 1904.

[Drainage area, 156 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	760	66	152	0.974	1.12
February	700	98	239	1.53	1.65
March	350	107	150	.962	1.11
April	134	82	101	.647	.722
May	82	50	54.4	.349	.402
June	279	20	63.3	.406	.453
July	192	50	78.1	.501	.578
August	1,320	50	278	1.78	2.05
September	116	42	52.5	.337	.376
October	66	34	47.9	.307	.354
November	125	34	69.0	.442	.493
December	452	50	91.7	.588	.678
The year	1,320	20	115	.735	9.99

TALLAPOOSA RIVER AT BUCHANAN BRIDGE, NEAR TALLAPOOSA, GA.

This station was established as a bench-mark station October 21, 1901, by M. R. Hall. It is located at Buchanan Bridge, about 4 miles north

of Tallapoosa, Ga., and about 2 miles above the station on Tallapoosa River at Adderhold Bridge. Discharge measurements are made from the single-span iron highway bridge, having trestle approach of 100 feet on the right bank and 50 feet on the left bank. The initial point for soundings is the end of the bridge at the right bank, downstream side. The channel is straight for about 800 feet above and 1,000 feet below the station. The current is moderate above and swift below the measuring section. The banks rarely overflow. The bed of the stream is composed of rock and gravel, free from vegetation, and is probably constant. There is but one channel at all stages, broken at the higher levels by the piers and trestlework of the bridge. The bench mark is the top of the downstream end of the center floor beam, the third from either end. Its elevation is 25.25 feet above gage datum.

Discharge measurements of Tallapoosa River at Buchanan Bridge, near Tallapoosa, Ga., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
March 26	W. E. Hall	71	161	1.12	1.55	180
May 14	J. M. Giles	39	96	.41	.83	39
July 19	W. E. Hall	39	89	.25	.65	22
August 31	J. M. Giles	38	99	.59	.81	59
September 26	A. T. Mitchelson	40	90	.37	.71	33

TALLAPOOSA RIVER AT ADDERHOLD BRIDGE, NEAR TALLAPOOSA, GA.

This station was established as a bench-mark station January 7, 1901, by M. R. Hall. It is located at Adderhold Bridge, about 2 miles north of Tallapoosa, Ga., and about 2 miles below the station on Tallapoosa River at Buchanan Bridge. Discharge measurements are made from the downstream side of the single-span iron highway bridge, which has trestle approaches at either end. The initial point for soundings is the end of the bridge at the left bank, downstream side. The channel is straight for about 300 feet above and 500 feet below the station. The current is swift above and sluggish below. Both banks are wooded and are subject to overflow under the trestle approaches during high water. The bed of the stream is composed of sand, and probably constant. There is but one channel at all stages, broken during the higher levels by the piers and trestlework of the bridge. The bench mark is the top of the downstream end of the first floor beam from the left bank. Its elevation is 22.00 feet above gage datum.

Discharge measurements of Tallapoosa River at Adderhold Bridge, near Tallapoosa, Ga., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
March 9	W. E. Hall	78	250	1.10	1.20	274
March 26	M. R. and W. E. Hall.	75	232	.94	1.22	218
May 14	J. M. Giles	65	168	.35	.60	59
July 19	W. E. Hall	75	159	.20	.30	32
August 31	J. M. Giles	78	205	.39	.65	80
September 26	A. T. Mitchelson	78	181	.27	.39	50

TALLAPOOSA RIVER NEAR HEFLIN, ALA.

This station was established as a bench-mark station. It is located at Denman's wagon bridge, about 7 miles southwest of Heflin, Ala., on the road to Wedowee, Ala. The elevation of the water surface at the time of each discharge measurement is referred to a common datum. Discharge measurements are made from the downstream side of the two-span wooden bridge resting upon three trestle bents and short trestle approaches on each side. The floor of the bridge is about 20 feet above low water. The initial point for soundings is at the center of the trestle bent at the left end of the bridge on the downstream side. The channel is straight for about 800 feet above and 500 feet below the station. The current is moderate above and sluggish below the measuring section. The right bank is high, but is subject to overflow during high stages. The left bank is high and overflows only at extreme high water. The bed of the stream is composed of gravel, free from vegetation. There is but one channel at all stages, broken by the pile supports of the bridge. The section is a fairly good one. At an old ford a short distance below, the section is good for wading. The bench mark is the top of the downstream end of the cap beam of the center pile bent of the bridge. Its elevation is 24.00 feet above gage datum.

Discharge measurements of Tallapoosa River near Heflin, Ala., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Foot per sec.*	*Feet.*	*Second-feet*
September 24	A. T. Mitchelson	107	201	0.68	1.18	137
November 3	J. M. Giles	90	142	.44	.80	62
November 4	do	98	173	.53	1.15	92
December 14	do	114	267	.68	1.67	181
December 15	do	114	249	.65	1.60	162

TALLAPOOSA RIVER AT STURDEVANT, ALA.

This station was established July 19, 1900, by J. R. Hall. It is located at the Columbus and Western Railroad bridge, a fourth of a mile west of Sturdevant. This railroad belongs to the Central of Georgia Railway. This station, being above the big new dams at Tallassee, is intended to replace Milstead station. Map and profile of Tallapoosa River is published in Twenty-second Annual Report, part 4. The gage is a vertical timber in two sections. The first section, reading from zero to 5.2 feet, is fastened to a post on the east bank about 20 feet below the bridge. The second section, reading from 5 to 20 feet, is fastened to the east side of the first pier in the water on the east bank. The gage is read once each day by C. J. Stowe, who is paid by the Alabama Geological Survey. At ordinary stages discharge measurements are made from a footway supported by the bracing of the lower chord of the deck bridge. At low stages measurements are made from a boat or by wading about 2,000 feet upstream or about 500 feet below the bridge. The initial point for soundings is the end of the iron bridge on the east or left bank, downstream side. Distances are marked in white paint along the hand rail of the footway.

The channel is slightly curved directly above the bridge and for about one-half mile below. The current is swift and much broken by shoals below the bridge, but is sluggish at low stages at and near the station. Both banks are high, the right overflowing for about 150 feet and the left for about 200 feet. The bed is of rock and gravel and is probably permanent.

Bench mark No. 1 is a wire nail driven in the southwest corner of the second pier on the east bank. Its elevation is 14.20 feet above the zero of the gage. Bench mark No. 2 is a copper plug set in solid rock in the bed of the river about 80 feet below the bridge, at a point 400 feet from the end of the bridge at the left bank. This is solid bed rock projecting above the water at ordinary stages. Its elevation is 4.89 feet above the zero of the gage. Bench mark No. 3 is a white paint mark on the top of the downstream end of the lower crossbeam at a point 278 feet from the initial point for soundings. Its elevation is 27.65 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Tallapoosa River at Sturdevant, Ala., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
May 22	J. M. Giles	378	3,274	1.40	4.00	4,580
July 25[a]	do	228	1,068	2.10	2.45	2,247
August 22[a]	do	236	1,096	1.68	2.20	1,837
August 24	do	269	2,070	.71	1.88	1,485
August 24[a]	do	190	831	1.94	1.86	1,616
October 3[a]	do	165	650	1.28	1.05	834
October 3	do	181	646	1.29	1.05	835
November 24[a]	do	190	806	1.42	1.58	1,148
1904.						
January 25	J. M. Giles	389	2,894	1.28	3.57	3,718
March 11	W. E. Hall	370	2,742	1.04	3.05	2,866
April 12	J. M. Giles	321	2,310	.87	2.40	2,011
May 28[a]	do	165	553	1.08	.65	599
May 28[a]	do	165	558	1.06	.65	592
August 25	do	317	2,219	.74	2.12	1,643
August 26	do	375	2,626	1.13	3.14	2,978
August 27	do	399	3,505	2.37	5.50	8,292
October 13[a]	do	135	422	.77	.03	324
October 13[b]	do	67	305	1.07	.03	326
October 13[c]	do	60	242	1.25	.03	303
October 18[b]	do	66	309	.91	— .10	282
October 18[b]	do	66	301	.91	— .10	273
October 18[b]	do	66	300	.90	— .10	270
December 12[a]	do	180	671	1.47	1.45	984

[a] At shoal one-third mile above Central of Georgia Railroad bridge.
[b] From boat 150 yards below bridge.
[c] From boat 200 yards below bridge.

Main daily gage height, in feet, of Tallapoosa River at Sturdevant, Ala., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.7	2.6	2.8	2.2	1.8	3.2	2.3	3.0	1.6	0.5	−0.1	0.9
2	1.7	2.8	2.9	2.2	1.9	2.5	2.0	2.8	1.4	.4	.0	1.0
3	1.8	2.6	3.3	2.1	1.8	2.1	1.9	2.3	1.3	.3	.1	1.4
4	1.8	2.7	2.9	2.1	1.7	1.8	1.8	3.1	1.2	.2	.3	1.5
5	1.7	2.7	2.8	2.0	1.6	1.6	1.5	5.4	1.1	.2	.7	1.9
6	1.7	2.9	2.6	2.0	1.5	1.5	1.1	5.1	1.1	.1	.9	2.5
7	1.8	3.4	4.9	2.2	1.5	1.4	1.4	5.6	1.6	.1	.9	2.5
8	1.9	5.8	4.2	3.4	1.5	1.2	1.2	13.4	1.6	.1	.8	2.3
9	2.4	5.1	3.9	3.4	1.4	1.1	.6	9.1	1.3	.1	.8	2.0
10	3.3	4.4	3.5	2.9	1.4	1.0	.6	8.5	1.1	.0	.8	1.7
11	2.8	5.3	3.1	2.7	1.4	.9	.8	7.1	1.0	.0	.7	1.5
12	2.5	4.8	2.9	2.4	1.3	.9	1.3	6.0	.9	.0	.6	1.4
13	2.3	4.1	2.7	2.2	1.3	.7	3.0	4.3	.8	.0	.7	1.4
14	2.3	3.6	3.4	2.1	1.5	.6	1.6	3.5	.8	.0	.7	1.3
15	2.1	3.3	3.3	2.0	1.4	.6	1.0	3.0	.7	.0	.8	1.2
16	2.0	3.0	3.3	2.0	1.3	.5	.7	4.5	.7	.0	.9	1.2
17	3.9	2.9	3.0	2.0	1.3	.5	.6	3.2	.6	.0	.8	1.3
18	3.4	2.8	2.9	1.9	1.2	.4	.5	3.8	.6	− .1	.9	1.3
19	3.2	2.8	2.8	1.9	1.2	.3	1.5	3.0	.6	− .1	.8	1.2
20	3.0	3.6	2.7	1.9	1.1	.2	.6	2.5	.5	.0	.9	1.1
21	2.6	3.7	2.6	1.9	1.1	.2	.3	2.2	.5	.0	1.0	1.1
22	3.8	4.6	2.5	1.9	1.0	.4	.6	2.0	.9	− .1	1.2	1.1
23	5.4	5.1	2.5	1.9	.9	1.2	1.3	1.8	2.0	− .1	2.0	1.1
24	4.3	4.8	2.5	1.9	.9	1.4	2.8	1.5	2.6	− .1	1.9	1.1
25	3.6	4.1	2.4	1.8	.8	1.3	1.5	2.1	1.7	− .2	1.5	1.7
26	3.1	3.6	2.4	2.0	.7	1.0	1.0	3.5	1.0	− .2	1.3	1.8
27	2.8	3.2	2.4	1.9	.7	.9	.7	5.0	.8	− .2	1.1	3.4
28	2.5	3.1	2.4	2.0	.6	.8	.7	3.5	.7	− .2	1.0	4.8
29	2.5	2.9	2.4	2.1	.6	4.4	1.2	2.6	.6	− .2	.9	4.0
30	2.4	.....	2.3	2.0	.6	2.3	2.5	2.3	.5	− .1	.9	2.9
31	2.4	.....	2.2	.....	2.8	.....	2.6	1.9	.....	− .1	.....	2.5

Rating table for Tallapoosa River at Sturdevant, Ala., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
−0.20	250	1.00	774	2.40	1,985	4.80	6,250
− .10	275	1.10	834	2.60	2,230	5.00	6,740
.00	305	1.20	897	2.80	2,495	5.20	7,240
.10	339	1.30	963	3.00	2,780	5.40	7,760
.20	377	1.40	1,032	3.20	3,085	5.60	8,300
.30	418	1.50	1,105	3.40	3,410	5.80	8,860
.40	462	1.60	1,182	3.60	3,755	6.00	9,430
.50	509	1.70	1,264	3.80	4,120	7.00	12,380
.60	558	1.80	1,352	4.00	4,500	8.00	15,480
.70	609	1.90	1,446	4.20	4,900	9.00	18,690
.80	662	2.00	1,545	4.40	5,330		
.90	717	2.20	1,757	4.60	5,780		

The preceding table is based upon fifteen discharge measurements made during 1904 and some during 1903. Above 6 feet it is based on four measurements made in 1905.

Estimated monthly discharge of Tallapoosa River at Sturdevant, Ala., for 1904.

[Drainage area, 2,500 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	7,760	1,264	2,500	1.00	1.15
February	8,860	2,230	4,089	1.64	1.77
March	6,490	1,757	2,749	1.10	1.27
April	3,410	1,352	1,757	.703	.784
May	2,495	558	991	.396	.456
June	5,330	377	1,084	.434	.484
July	2,780	418	1,086	.434	.500
August	34,200	1,105	5,855	2.34	2.70
September	2,230	509	850	.340	.379
October	509	250	314	.126	.145
November	1,545	275	722	.290	.324
December	6,250	717	1,562	.625	.721
The year	34,200	250	1,966	.786	10.68

LITTLE TALLAPOOSA RIVER 3 MILES NORTH OF WEDOWEE, ALA.

This station was established as a bench-mark station. It is located at "Iron" highway bridge, 3 miles north of Wedowee, Ala., on the Wedowee-Heflin road. Discharge measurements are made from the downstream side of the single-span bridge, the floor of which is 26 to 28 feet above low-water surface. The initial point for soundings is the end of the bridge at the left bank, downstream side. The channel is straight for about 1,000 feet above and 800 feet below the station. The current is moderate. The right bank is fairly high, fringed with trees, and overflows during high water. The left bank is high, wooded above, and cultivated below the bridge, and not subject to overflow. The bed of the stream is composed of clean gravel. There is but one channel at all stages. There is a small sand reef just above the bridge near the right bank; otherwise, this is a good section. Bench mark No. 1 is the top of the large nut on pin connecting eyebars of lower chord at end of first floor beam from the left bank on the downstream side of the bridge. Its elevation is 25.00 feet above gage datum. Bench mark No. 2 is a chisel mark on the intermediate post above the same, downstream end of first floor beam. Its elevation is 32.00 feet above gage datum.

Discharge measurements of Little Tallapoosa River 3 miles north of Wedowee, Ala., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
September 23 ..	A. T. Mitchelson	130	431	0.54	1.48	236
November 3 ...	J. M. Giles	115	385	.26	1.20	102

LITTLE TALLAPOOSA RIVER 6 MILES NORTHWEST OF WEDOWEE, ALA.

This station was established as a bench-mark station. It is located at the highway bridge about 6 miles northwest of Wedowee and several miles above the mouth of the river. Discharge measurements are made from the downstream side of the iron bridge, which consists of a single span of 140 feet with trestle approaches 100 feet long at each end. The floor of the bridge is about 28 feet above low water. The initial point for soundings is the center of the pier at the left bank, downstream side. The channel is straight for about 500 feet above and 1,000 feet below the station. The current is swift. Both banks are clean, and overflow only under the trestle approach. The bed of the stream is composed of rock and gravel, free from vegetation, and is constant. There is but one channel at low water, broken at high water by the piers and trestle approach of the bridge. Bench mark No. 1 is the downstream end of the second floor beam from the left bank. Its elevation is 27.00 feet above gage datum. Bench mark No. 2 is a chisel mark on the intermediate post at this floor beam. Its elevation is 32.00 feet above gage datum.

Discharge measurements of Little Tallapoosa River 6 miles northwest of Wedowee, Ala., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
November 4 ...	J. M. Giles	120	283	0.44	0.70	124
December 14...	.....do	125	329	.64	1.02	211
December 15...	.....do	125	327	..65	1.02	214

CAHABA RIVER AT CENTERVILLE, ALA.

The station was established on August 7, 1901, and is situated at the iron highway bridge one-fourth mile west of Centerville, Ala., one-half mile above the Mobile and Ohio Railroad bridge. The bridge is a single span supported by tubular iron piers.

The chain gage is fastened to the timber fencing along the downstream side of the bridge. The pulley is 100 feet from the initial

point, which is the end of the iron bridge on the left bank, downstream side. The length of the chain from the end of the weight to the marker is 51.35 feet. The observer is Clyde Lowrey, who is paid by the Alabama Geological Survey.

The channel is straight for 1,500 feet above the station and for one-half mile below. The current is swift. The right bank overflows at extreme high water. The left bank overflows only under the approach to the bridge. The bed is nearly all rock, and there is but one channel.

Bench mark No. 1 is the downstream end of the floor beam 100 feet from the initial point for soundings and is 42.85 feet above gage datum. Bench mark No. 2 is a copper plug set in a solid rock about 6 feet from the edge of the water and 250 feet below the bridge on the left bank. Its elevation is 6.44 feet above gage datum.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Cahaba River at Centerville, Ala., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
April 8 [a]	J. M. Giles	161	906	1.80	5.15	1,637
April 9 [b]	do	180	1,834	1.21	6.65	2,225
June 17 [a]	do	125	416	1.00	2.05	416
June 18 [a]	do	125	414	.95	2.00	394
July 20 [a]	do	140	591	1.28	3.23	757
July 21 [a]	do	127	482	1.07	2.36	516
September 28 [a]	do	107	311	.68	1.31	212
September 29 [a]	do	100	314	.69	1.30	218
November 8 [a]	do	110	338	.60	1.32	203
November 10 [a]	do	100	329	.68	1.40	223
1904.						
February 22	Murphy & Giles	145	556	1.54	3.47	856
June 25 [c]	J. M. Giles	100	207	1.00	1.29	208
August 3	do	128	315	1.33	1.97	419
August 4	do	128	304	1.25	1.88	381
October 31	do	113	189	.54	.86	103
October 31	do	113	196	.55	.88	108

[a] Measurement taken at wagon bridge.
[b] Measurement taken at Mobile and Ohio Railroad bridge.
[c] Channel silted badly.

Mean daily gage height, in feet, of Cahaba River at Centerville, Ala., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.5	2.9	2.6	2.2	1.6	1.5	1.3	1.6	1.2	1.0	0.9	1.1
2	1.5	2.9	2.5	2.3	1.6	1.4	1.4	1.6	1.2	1.0	.9	1.1
3	1.6	2.9	2.4	2.2	1.6	1.2	1.3	2.0	1.1	.9	1.3	1.1
4	1.5	2.7	2.3	2.1	1.6	1.2	1.5	2.2	1.7	.9	1.3	1.1
5	1.5	2.6	2.2	2.1	1.5	1.2	1.4	2.0	1.5	.9	1.1	2.0
6	1.5	2.8	3.0	2.1	1.5	1.2	1.3	2.0	1.4	.9	1.1	2.2
7	1.8	6.7	6.4	2.2	1.4	1.3	1.8	7.1	1.2	.9	1.0	2.0
8	1.9	11.5	7.0	2.6	1.5	2.5	1.2	5.5	1.3	.9	1.0	1.9
9	2.2	6.0	5.4	3.1	1.5	1.7	1.6	5.1	1.3	1.0	1.0	1.7
10	2.8	6.4	4.2	2.6	1.6	1.6	1.7	4.7	1.2	1.0	1.0	1.5
11	3.1	10.0	3.8	2.4	1.6	1.6	1.5	3.7	1.1	1.0	1.0	1.4
12	2.2	7.2	3.4	2.3	1.7	1.4	1.3	3.7	1.2	.9	1.0	1.4
13	2.0	5.5	3.1	2.2	1.6	1.3	1.2	3.8	1.1	.9	1.0	1.4
14	1.8	5.4	3.8	2.1	1.6	1.3	1.3	2.8	1.1	.9	1.0	1.3
15	1.8	4.6	5.4	2.1	1.5	1.2	1.2	5.6	1.1	.9	1.0	1.3
16	1.8	4.1	4.3	2.0	1.4	1.2	1.2	3.6	1.0	.9	1.0	1.2
17	2.9	3.3	3.9	2.0	1.4	1.1	1.3	2.5	1.0	.9	1.0	1.2
18	2.6	3.1	3.6	2.0	1.3	1.1	1.3	2.0	1.0	.9	1.0	1.2
19	2.4	3.0	3.5	1.9	1.3	1.1	1.2	1.8	1.0	.9	1.0	1.2
20	2.1	3.8	3.3	1.9	1.3	1.1	1.1	1.6	1.1	.9	1.0	1.2
21	2.0	3.3	3.0	1.8	1.3	1.0	1.1	1.4	1.1	.9	1.2	1.2
22	10.2	3.5	2.9	1.7	1.3	1.0	1.1	1.4	1.0	.9	1.2	1.1
23	8.8	3.3	2.8	1.7	1.2	1.0	1.6	1.3	1.0	.9	1.3	1.1
24	4.8	3.2	2.8	1.6	1.2	1.2	1.3	1.3	1.0	.8	1.3	1.1
25	3.4	3.1	2.7	1.6	1.2	1.3	1.3	1.2	1.0	.8	1.3	1.7
26	3.0	3.0	2.6	1.7	1.2	1.2	1.2	1.5	1.0	.8	1.2	2.0
27	2.4	2.9	2.4	1.7	1.2	1.3	1.4	1.3	1.0	.8	1.1	3.1
28	2.6	2.8	2.3	1.6	1.3	1.2	2.1	1.3	1.0	.8	1.1	4.7
29	2.7	2.7	2.2	1.6	1.2	1.1	1.7	1.2	1.0	.8	1.1	6.0
30	2.9	.....	2.1	1.6	1.4	1.0	1.7	1.5	1.0	.9	1.1	5.1
31	2.8	.....	2.0	.....	1.6	.....	1.6	1.3	.....	.9	.....	2.6

Rating table for Cahaba River at Centerville, Ala., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.80	90	1.70	318	2.50	560	3.60	911
.90	111	1.80	348	2.60	591	3.80	982
1.00	133	1.90	378	2.70	622	4.00	1,056
1.10	156	2.00	408	2.80	653	4.20	1,131
1.20	180	2.10	438	2.90	684	4.40	1,207
1.30	205	2.20	468	3.00	715	4.60	1,285
1.40	232	2.30	498	3.20	779	4.80	1,366
1.50	260	2.40	529	3.40	844	5.00	1,450
1.60	289						

The above table is based upon discharge measurements made during 1903 and 1904. It is fairly well defined between gage heights 0.8 foot and 3.5 feet. Above 3.5 feet the curve is uncertain, as the high-water measurements are inconsistent.

Estimated monthly discharge of Cahaba River at Centerville, Ala., for 1904.

[Drainage area, 1,040 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maxium.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	4,215	260	721	0.693	0.799
February	5,060	591	1,290	1.24	1.34
March	2,395	408	866	.833	.96[illegible]
April	747	289	419	.403	.45[illegible]
May	318	180	241	.232	.26[illegible]
June	560	133	205	.197	.22[illegible]
July	438	156	233	.224	.25[illegible]
August	2,445	180	623	.599	.691
September	318	133	165	.159	.177
October	133	90	110	.106	.122
November	205	111	153	.147	.164
December	1,900	156	397	.382	.44[illegible]
The year	5,060	90	452	.435	5.89

TOMBIGBEE RIVER AT COLUMBUS, MISS.

The gage is located about 1,000 feet below the county highway bridge, 1 mile from the Southern Railway station at Columbus, Miss. A vertical 3 by 10 inch pine timber is fastened to the blue-rock bluff on the left bank and is marked with brass figures and brass nails from −5 to +43 feet. Discharge measurements are made from the county highway bridge at the south end of Main street. The initial point for soundings is the end of the iron bridge on the right bank, downstream side. The channel is slightly curved for 500 feet above and 1,000 feet below the station. The current is sluggish at low stages and very swift above a gage height of 12 feet. The right bank is high and seldom overflows. The left bank overflows from gage height 18 to 22 feet. The bed of the stream is of soft blue rock.

Bench mark No. 1 is the top of the downstream girder at a point 250 feet from the initial point for soundings. Its elevation is 39.8[illegible] feet above the zero of the gage. This point is on the movable portion of the drawbridge and may vary in elevation. Bench mark No. 2 is a copper plug in a tree at the southeast corner of First street and Second avenue. Its elevation is 17.94 feet above the zero of the gage. This tree has boards nailed to it, showing the names of the streets. Bench mark No. 3 is the top of the rail at the depot of the Southern Railway and is 55.20 feet above gage datum and 191 feet above mean sea level.

The observer, J. J. Richards, is paid by the United States Weather Bureau.

The width of the river at low water is 160 feet. The maximum recorded height of the river was on April 8, 1892, when the gage registered 42 feet. The lowest recorded height was on October 26, 1893, when the gage reading was −3.9 feet. The danger line is at 33 feet.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Tombigbee River at Columbus, Miss., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
March 9	J. M. Giles	307	5,884	4.49	15.50	26,450
March 12	do	317	6,586	4.40	17.30	29,020
May 18	do	297	4,655	3.82	12.50	17,800
July 16	do	88	1,040	1.29	− 1.70	1,340
July 17	do	88	1,034	1.24	− 1.80	1,278
September 22	do	55	805	.31	− 3.70	252
September 25[a]	do	116	187	1.40	− 3.70	263
1904.						
January 13	J. M. Giles	104	1,072	1.06	− 1.80	1,137
January 16	do	105	1,107	.97	− 2.00	1,072
February 25	J. M. Giles and E. C. Murphy.	119	1,230	1.86	− .30	2,290
March 23	W. E. Hall	133	1,359	2.14	.30	2,913
August 13	J. M. Giles	120	1,216	1.87	− .50	2,270
October 29[b]	do	66	128	1.27	− 3.80	162
October 29[b]	do	66	128	1.23	− 3.80	58

[a] Measured 1 mile below wagon bridge, which is about one-third mile below the Mobile and Ohio Railroad bridge.
[b] From boat at shoal, one-third mile below Mobile and Ohio Railroad bridge.

Mean daily gage height, in feet, of Tombigbee River at Columbus, Miss., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	−1.8	1.6	−1.3	4.6	−1.3	−2.3	−1.6	−1.8	−3.3	−2.8	−3.1	−2.2
2	−1.9	1.0	− .8	5.3	−1.3	−2.4	−1.6	−1.8	−3.3	−2.8	−3.0	−2.2
3	−1.6	.4	− .6	6.0	−1.3	−2.4	−1.7	−1.2	−3.2	−2.9	−2.8	−2.1
4	−1.4	.0	− .6	6.2	−1.5	−2.3	−1.5	−1.2	−3.2	−2.9	−2.4	−1.6
5	−1.4	− .4	− .8	6.0	−1.6	−2.3	−1.7	−1.1	−3.2	−2.9	−2.4	−1.6
6	−1.6	− .4	− .5	6.0	−1.6	−2.4	−1.7	−1.0	−3.2	−2.9	−2.4	−1.6
7	−1.4	− .3	− .1	5.5	−1.6	−1.8	−1.9	− .9	−3.3	−2.9	−2.4	−1.6
8	−1.4	− .3	− .2	5.2	−1.6	−1.5	−1.9	− .7	−3.3	−2.9	−2.4	−1.6
9	−1.6	− .6	− .1	5.0	−1.6	−1.5	−1.8	− .7	−3.3	−2.9	−2.4	−1.6
10	−1.6	− .4	− .1	4.6	−1.6	−1.6	−1.9	− .6	−3.4	−2.9	−2.4	−1.6
11	−1.6	− .2	1.0	4.2	−1.8	−1.8	−1.9	− .6	−3.4	−2.9	−2.4	−1.7
12	−1.6	− .2	1.0	4.0	−1.8	−1.8	−1.8	.0	−3.5	−2.9	−2.4	−1.8
13	−1.5	− .5	1.0	3.7	−1.9	−1.9	−1.8	− .4	−3.5	−2.9	−2.5	−1.8
14	−1.6	− .7	1.2	2.4	−2.0	−1.9	−2.0	− .8	−3.5	−2.9	−2.6	−1.8
15	−1.7	− .8	1.3	3.0	−2.2	−2.0	−2.2	−1.0	−3.5	−2.9	−2.6	−1.8
16	−1.7	−1.0	1.3	2.8	−2.3	−2.0	−2.6	−2.0	−3.5	−3.0	−2.6	−1.8
17	−2.0	−1.1	1.0	2.0	−2.3	−2.0	−2.6	−2.5	−3.5	−3.0	−2.6	−1.8
18	−1.9	−1.2	1.7	1.6	−2.3	−2.0	−2.7	−2.9	−3.5	−3.0	−2.6	−1.8
19	−1.9	−1.2	1.6	.8	−2.4	−2.1	−2.8	−2.9	−3.5	−3.0	−2.6	−1.8
20	−1.9	−1.1	1.4	.4	−2.4	−2.2	−2.9	−2.9	−3.5	−3.0	−2.6	−1.8
21	−2.0	−1.0	1.7	.1	−2.4	−2.2	−2.9	−3.1	−3.5	−3.0	−2.6	−1.8
22	−1.6	− .8	1.7	.0	−2.4	−2.2	−2.8	−3.2	−3.2	−3.0	−2.4	−1.8
23	−1.6	−1.0	1.7	− .3	−2.4	−2.3	−2.2	−3.2	−3.2	−3.0	−2.4	−1.8
24	.0	− .9	1.4	− .5	−2.4	−2.3	−2.0	−3.1	−2.8	−3.0	−2.4	−1.9
25	1.0	− .9	1.4	− .6	−2.5	−2.3	−1.9	−3.1	−2.8	−3.0	−2.4	−1.8
26	.....	− .3	2.6	− .6	−2.5	−2.3	−1.9	−3.1	−2.8	−3.0	−2.5	−1.7
27	1.7	− .7	2.8	− .8	−2.5	−2.3	−1.5	−3.1	−2.8	−3.0	−2.5	−1.5
28	1.9	− .9	2.9	− .9	−2.5	−1.8	− .8	−3.2	−2.8	−3.0	−2.5	−1.4
29	2.0	−1.3	3.5	−1.0	−2.5	−2.0	− .8	−3.2	−2.8	−3.0	−2.5	−1.3
30	1.4	.....	3.5	−1.2	−2.5	−1.8	−1.2	−3.3	−2.8	−3.1	−2.2	−1.5
31	1.6	.....	3.5	.....	−2.3	.....	−1.5	−3.3	.....	−3.1	.....	−2.1

Rating table for Tombigbee River at Columbus, Miss., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
−4.00	100	−2.80	620	−0.60	2,120	1.60	4,210
−3.90	130	−2.60	720	− .40	2,290	1.80	4,430
−3.80	160	−2.40	830	− .20	2,470	2.00	4,650
−3.70	190	−2.20	950	.00	2,650	2.50	5,200
−3.60	230	−2.00	1,070	.20	2,830	3.00	5,800
3.50	270	−1.80	1,200	.40	3,010	3.50	6,400
−3.40	320	−1.60	1,340	.60	3,200	4.00	7,050
−3.30	370	−1.40	1,480	.80	3,400	4.50	7,700
−3.20	420	−1.20	1,640	1.00	3,600	5.00	8,350
−3.10	470	−1.00	1,800	1.20	3,800	5.50	9,000
−3.00	520	− .80	1,960	1.40	4,000	6.00	9,700

The above table is based upon discharge measurements made from 1901 to 1904. It is fairly well defined. Above 7 feet the 1903 and 1904 rating tables are identical.

Estimated monthly discharge of Tombigbee River near Columbus, Miss., for 1904.

[Drainage area, 4,440 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	4,650	1,070	1,991	0.448	0.516
February	4,210	1,560	2,209	.498	.537
March	6,400	1,560	3,785	.852	.982
April	9,980	1,640	5,456	1.23	1.37
May	1,560	770	1,059	.239	.276
June	1,410	830	1,041	.234	.261
July	1,960	570	1,135	.256	.295
August	2,650	370	1,175	.265	.306
September	620	270	402	.091	.102
October	620	470	544	.123	.142
November	950	470	765	.172	.192
December	5,200	950	1,475	.332	.383
The year	9,980	270	1,753	.395	5.36

BLACK WARRIOR RIVER NEAR CORDOVA, ALA.

This station is located at the Kansas City, Memphis and Birmingham Railroad bridge, which crosses the river below the junction of the Mulberry and Sipsey forks, and about three-fourths of a mile from Cordova, Ala. The gage was established by the United States Weather Bureau, but observations by that bureau have been discontinued. From 12 to 55 feet the gage is a vertical timber bolted to the inside of the bridge pier on the left bank of the river. Below 12 feet the gage was sloping, but it was out of position and could not be used when the station was established by the United States Geological Survey on May 21, 1900, so a short new section was put in at that time. This section is a 2 by 10 inch plank, graduated to feet and tenths, from −1.5 to +12.5 feet, and spiked to a willow tree on the right bank of the river about 200 feet below the bridge.

Measurements are made from the downstream side of the railroad bridge, which is a two-span iron through bridge. The span across the river is 300 feet long. A pier is being built in the river, and the long span will be replaced by two shorter ones. The span on the left bank is about 150 feet long. At low stages discharge measurements are made from a boat or by wading at a point some distance below the bridge. The channel is curved for 500 feet above and straight for 1,000 feet below the station. The right bank is a rock bluff and will not overflow. The left bank overflows only under the second span of the bridge. The bed of the stream is of rock and is permanent. The

channel has a width of about 180 feet at low water and about 450 feet at high stages.

Bench mark No. 1 is the top of the fourth crossbeam from the right bank, on the downstream side. Its elevation is 60.09 feet above the zero of the gage. Bench mark No. 2 is a copper plug in the solid rock about 110 feet above the bridge, 50 feet from the initial point for soundings. Its elevation is 32.12 feet above the zero of the gage. The top of the pier at the left bank is 55.10 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Black Warrior River near Cordova, Ala., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
March 6	J. M. Giles	240	4,225	4.56	13.90	19,250
March 13	do	220	2,625	3.61	6.90	9,486
May 19	do	206	1,991	2.59	4.34	5,159
June 15	do	184	1,261	.82	.50	1,03[illegible]
July 17 [a]	do	178	576	.53	— .30	[illegible]
August 27 [b]	do	182	546	.38	— .48	[illegible]
August 29 [b]	do	181	501	.28	— .65	14[illegible]
September 25 [c]	do	137	134	.58	— .90	[illegible]
1904.						
January 16 [a]	J. M. Giles	182	554	.39	— .40	216
February 24	J. M. Giles and E. C. Murphy.	181	1,200	.65	.28	78[illegible]
March 23	M. R. and W. E. Hall.	191	1,638	1.88	2.65	3,08[illegible]
May 25 [b]	J. M. Giles	180	509	.34	— .50	171
August 10	do	185	1,263	.80	.49	1,01[illegible]
October 26 [d]	do	48	75	.34	— 1.00	[illegible]
October 26 [d]	do	48	72	.34	— 1.00	24

[a] One-fourth mile below Frisco System Railroad bridge.
[b] One-third mile below Frisco System Railroad bridge.
[c] At fish trap 3 miles below bridge.
[d] Boat 100 yards above Southern Railway bridge.

Mean daily gage height, in feet, of Black Warrior River near Cordova, Ala., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	−0.4	−0.1	0.0	2.6	−0.5	1.2	1.8	−0.5	−0.8	−1.0	−0.9	0.8
2	− .4	.0	.0	2.4	− .5	.4	.2	− .3	− .8	−1.0	− .9	.9
3	− .5	.1	.0	3.2	− .5	− .1	− .3	.6	− .8	−1.0	− .9	1.3
4	− .5	.0	.0	3.1	− .4	− .6	− .1	.4	− .5	−1.0	− .3	2.2
5	− .5	− .1	.0	2.8	− .4	− .4	− .3	.4	− .5	−1.0	.1	3.8
6	− .5	− .1	.0	2.4	− .5	− .3	− .3	.6	− .6	−1.0	.3	5.5
7	− .5	− .1	3.2	3.7	− .5	− .2	.2	.6	− .7	−1.0	− .3	2.7
8	− .4	.3	5.4	5.2	.3	− .1	− .1	1.2	− .8	−1.0	− .4	1.3
9	− .4	.1	3.5	7.2	.4	− .3	− .3	1.0	− .8	−1.0	− .4	1.1
10	− .5	.4	2.3	4.3	.6	− .4	− .4	.9	− .8	−1.0	− .5	1.2
11	− .5	.7	2.0	4.0	.5	− .5	− .2	1.1	− .8	− .9	− .5	.9
12	− .5	.6	2.0	3.2	.4	− .5	.3	1.1	− .8	− .9	− .5	.7
13	− .5	.4	2.4	2.5	.2	− .5	2.7	1.2	− .8	− .9	− .5	.4
14	− .5	.4	5.5	2.1	.0	− .5	.6	.8	− .8	− .9	− .5	.2
15	− .5	.3	6.8	1.6	− .1	− .5	− .1	.3	− .8	− .9	− .5	.1
16	− .5	.2	4.5	1.5	− .2	− .5	− .4	.1	− .8	− .9	− .6	.0
17	− .3	.1	3.2	1.2	− .2	− .6	− .3	.1	− .8	− .9	− .6	− .1
18	− .3	.1	2.5	1.1	− .3	− .6	− .5	.0	− .8	− .9	− .6	− .1
19	− .2	.0	2.2	1.0	− .4	− .6	− .3	− .1	− .9	− .9	− .6	.0
20	− .2	.0	1.4	1.0	− .5	− .6	− .5	− .2	− .9	− .9	− .6	.0
21	− .2	.3	.5	1.0	− .6	− .7	− .4	− .2	− .9	− .9	− .6	− .1
22	1.3	.3	.3	1.1	− .6	− .7	− .4	− .3	− .9	− .9	− .6	− .1
23	2.9	.4	.3	1.5	− .6	− .8	− .5	− .4	− .9	− .9	− .1	− .2
24	2.0	.3	5.5	1.4	− .6	− .8	− .4	− .5	− .9	− .9	.1	− .2
25	1.6	.3	5.5	− .1	− .6	− .5	− .3	− .6	− .9	− .9	.1	− .2
26	.6	.2	4.1	− .1	− .6	− .5	− .3	− .7	− .9	− .9	.0	.0
27	.3	.1	6.5	− .1	− .6	− .5	− .4	− .7	− .9	− .9	.0	.2
28	.1	.1	8.6	− .2	− .6	− .5	− .5	− .7	− .9	− .9	− .1	12.4
29	.1	.0	5.7	− .4	− .6	− .4	− .5	− .7	−1.0	− .9	− .1	6.5
30	.0	.....	4.3	− .5	− .6	2.6	− .5	− .8	−1.0	− .9	− .1	3.8
31	.0	.....	2.8	.....	1.3	.....	− .5	− .8	.....	− .9	.....	2.4

Rating table for Black Warrior River near Cordova, Ala., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
—1.00	28	0.00	560	1.00	1,450	3.00	3,540
— .90	53	.10	645	1.20	1,630	3.20	3,780
— .80	80	.20	730	1.40	1,820	3.40	4,030
— .70	110	.30	820	1.60	2,010	3.60	4,290
— .60	145	.40	910	1.80	2,210	3.80	4,550
— .50	190	.50	1,000	2.00	2,410	4.00	4,820
— .40	250	.60	1,090	2.20	2,615	4.50	5,520
— .30	320	.70	1,180	2.40	2,830	5.00	6,230
— .20	400	.80	1,270	2.60	3,060	5.50	6,955
— .10	480	.90	1,360	2.80	3,300	6.00	7,700

The above table is based upon twenty-six discharge measurements made during 1900–1904. It is well defined between gage heights —1.0 feet and 6.0 feet. The table has been extended beyond these limits, being based on three high-water measurements. Above gage height 6 feet the rating curve is a tangent, the difference being 150 per tenth.

Estimated monthly discharge of Black Warrior River near Cordova, Ala., for 1904.

[Drainage area, 1,900 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	3,420	190	613	0.323	0.372
February	1,180	480	720	.379	.409
March	11,600	560	3,818	2.01	2.32
April	9,500	190	2,606	1.37	1.53
May	1,725	145	409	.215	.248
June	3,060	80	378	.199	.222
July	3,180	190	516	.272	.314
August	1,630	80	693	.365	.421
September	190	28	78.0	.041	.046
October	53	28	44.9	.024	.028
November	645	53	298	.157	.175
December	17,300	400	2,277	1.20	1.38
The year	17,300	28	1,038	.546	7.46

BLACK WARRIOR RIVER AT TUSCALOOSA, ALA.

A continuous record of gage heights at Tuscaloosa since 1889 has been kept by the United States Engineer Corps. During 1895 and 1896 a number of discharge measurements were also made, from which a rating table was obtained, and since that time measurements of flow have been made by the United States Geological Survey. The station is located about one-fourth of a mile above Mobile and Ohio Railroad bridge. There are three locks and dams within about 3 miles above the station.

The gage is located about three-fourths of a mile from tne business center of Tuscaloosa, Ala. It is reached by passing down Bridge street to the river, thence down the east bank 1,800 feet. There is also a vertical iron gage on the downstream side of the second pier from the left bank of the highway bridge, from which the discharge measurements are made. Discharge measurements are made from the iron highway bridge above the gage. The initial point for soundings is the end of the iron bridge on the left bank, downstream side. The channel is straight for 15,000 feet above and below the station; its width at low water is 280 feet and at high stages 625 feet. The current is sluggish at low stages. Both banks are high and steep and overflow only at extreme stages. The greater part of the bed is of rock and is permanent. There is but one channel, broken by the three bridge piers.

Bench mark No. 1 is on a willow tree 10 feet west of the gage; its elevation is 10.54 feet above the zero of the gage and 97.34 feet above the Mobile datum. Bench mark No. 2 is on a small hackberry tree 30 feet south of the upper end of the gage; its elevation is 52.06 feet above the zero of the gage and 139.36 feet above the Mobile datum. Daily gage heights are furnished to the Geological Survey by the United States engineers.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Black Warrior River at Tuscaloosa, Ala., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
July 20	J. M. Giles	229	1,433	0.60	5.45	862
July 21	do	229	1,448	.50	5.44	719
1904.						
February 23	J. M. Giles and E. C. Murphy.	257	1,978	1.23	7.40	2,433
August 22	do	247	1,536	.66	5.57	1,021
August 22	do	247	1,532	.64	5.57	976

Mean daily gage height, in feet, of Black Warrior River at Tuscaloosa, Ala., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.02	6.40	6.57	13.06	6.85	5.10	8.15	5.29	4.90	4.38	4.12	.....
2	5.00	6.35	6.42	12.20	6.75	6.40	9.80	5.29	4.93	4.35	4.12	.....
3	5.03	6.40	6.40	12.25	6.40	6.91	8.10	5.55	4.82	4.36	4.23	.....
4	5.01	6.37	6.31	12.10	6.21	6.50	6.91	6.53	4.78	4.38	4.70	.....
5	4.98	6.30	6.23	11.05	5.98	6.01	6.63	6.89	4.60	4.40	4.70	.....
6	4.95	6.28	6.05	10.10	5.85	5.53	5.90	6.70	4.80	4.40	4.61	.....
7	5.06	6.30	9.30	9.91	5.64	5.50	5.45	7.32	4.87	4.29	4.66	.....
8	5.18	6.70	15.75	12.30	5.53	5.45	5.40	9.50	4.90	4.30	4.83	.....
9	5.10	7.68	17.50	18.48	5.42	5.35	6.00	9.90	4.85	4.29	4.75	.....
10	5.41	8.75	15.25	20.55	5.98	5.30	7.98	9.73	4.90	4.29	4.66	.....
11	5.32	11.05	12.94	18.13	6.17	5.31	7.71	8.17	4.80	4.30	4.65	.....
12	5.51	12.16	11.07	15.00	6.08	5.30	7.02	8.39	4.71	4.35	4.55	.....
13	5.40	10.73	10.21	13.13	5.96	5.28	7.22	10.30	4.70	4.33	4.48	.....
14	5.28	9.56	10.85	11.45	5.80	5.20	9.00	10.55	4.69	4.33	4.40	.....
15	5.15	8.70	17.60	10.20	5.63	5.10	8.82	9.24	4.65	4.33	4.36	.....
16	5.08	8.07	22.24	8.50	5.40	5.10	7.40	8.40	4.60	4.33	4.34	.....
17	5.32	7.53	19.00	8.45	5.21	5.00	7.00	7.52	4.50	4.15	4.30	.....
18	5.60	7.10	15.34	8.35	5.18	4.80	6.90	6.92	4.50	4.15	4.25	.....
19	5.50	6.80	13.10	8.15	5.10	4.70	5.50	6.87	4.50	4.15	4.30	.....
20	5.49	6.80	11.73	7.80	5.08	4.62	5.31	6.44	4.46	4.17	4.25	.....
21	5.50	7.05	10.71	7.45	5.06	4.60	5.23	6.16	4.45	4.17	4.27	.....
22	6.70	7.35	9.86	7.15	5.00	4.43	4.70	5.59	4.44	4.16	4.70	.....
23	11.68	7.45	9.25	7.09	5.00	4.30	5.10	5.33	4.43	4.15	4.71	.....
24	12.70	7.36	9.40	7.01	4.98	4.21	5.38	5.14	4.40	4.15	4.70	.....
25	11.15	7.31	14.00	7.40	4.95	3.98	5.60	5.08	4.40	4.15	4.59	.....
26	9.48	7.23	15.40	7.41	4.91	3.85	5.75	4.80	4.38	4.15	4.55	.....
27	8.20	7.12	14.71	7.20	4.88	4.54	5.40	4.84	4.35	4.15	4.57	.....
28	7.40	6.84	18.50	7.18	4.86	4.88	5.38	4.90	4.34	4.15	4.54	.....
29	6.90	6.71	20.60	7.15	4.80	4.80	5.40	4.98	4.40	4.15	4.44	.....
30	6.65	.....	17.85	7.10	4.81	4.75	5.12	5.15	4.40	4.14	4.25	.....
31	6.40	.....	15.03	.....	4.95	.....	5.24	4.78	.....	4.13	.....	.....

CLEAR CREEK NEAR ELK, ALA.

This station was established June 22, 1904, by M. R. Hall. It is located at the wagon bridge 1 mile south of Elk, and 15 miles north of Jasper, on the road to Houston. The bridge is about one-fourth mile above Clear Creek Falls, and about 2 miles above the junction of Clear Creek with Sipsey Fork of Black Warrior River. The gage is a vertical timber graduated from zero to 10 feet, fastened to a 3-inch by 4-inch pine timber which is bolted to the right side of the right-bank stone pier under the upstream side of the bridge. It is read once each day by J. S. Gossett. This station is maintained in cooperation with the Alabama Geological Survey, by whom the gage reader is paid. Discharge measurements are made from the upstream side of the bridge to which the gage is attached. This is an iron wagon bridge, having a single span of 100 feet, and a 49-foot trestle approach on the right bank. The initial point for soundings is the end of the bridge at the left bank on the upstream side. The channel is straight for about 400 feet above and 500 feet below the station. The current above the station is rather sluggish at low stages; below, it is swift and broken. The right bank is low, wooded, and is liable to overflow, but all the water passes under the bridge and trestle. The left bank is high, rocky, clean, and is not subject to overflow. The bed of the stream is composed of rock and clean sand, and is permanent. There is one channel at all stages. At very low water the current is too sluggish for measurement at the bridge, but measurements are made by wading at the falls below. Bench mark No. 1 is the top of the outer, upstream eyebar, at a point 35 feet from the initial point for soundings. Its elevation is 17.10 feet above the zero of the gage. Bench mark No. 2 is a copper plug set in rock on the left bank about 15 feet upstream from the end of the bridge. Its elevation is 17.04 feet above the zero of the gage.

Discharge measurements of Clear Creek near Elk, Ala., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
May 24	J. M. Giles	86	86	0.45	0.79	39
June 22 [a]	do	26	14	1.05	.66	15
August 9	do	96	84	.56	.81	47
October 25	do	94	77	.22	.65	17
October 25 [b]	do	34	19	.90	.65	17

[a] Wading at upper falls.

[b] Wading 150 yards below bridge.

Mean daily gage height, in feet, of Clear Creek near Elk, Ala., for 1904.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		0.80	0.75	0.85	0.65	0.65	0.90
2		.80	.75	.70	.65	.65	1.00
3		.80	.80	.70	.65	.80	1.00
4		.80	1.10	.70	.65	.80	1.30
5		.90	.95	.70	.65	.75	1.60
6		.90	.95	.65	.70	.75	1.60
7		.95	.90	.65	.70	.75	1.50
8		1.00	1.10	.70	.70	.75	1.4
9		1.10	.80	.70	.70	.80	.9
10		1.00	.80	.70	.65	.90	.9
11		.90	.75	.70	.65	.80	.9
12		1.10	.80	.65	.65	.75	.9
13		1.10	.80	.65	.65	.70	.8
14		.90	1.00	.65	.60	.70	.8
15		.90	1.00	.65	.60	.70	.8
16		.90	1.00	.60	.60	.70	.7
17		.85	1.00	.60	.60	.70	.7
18		.85	1.10	.60	.60	.70	.7
19		.85	1.00	.60	.60	.70	.7
20		.85	1.00	.60	.60	.70	.7
21		.95	1.00	.65	.60	.70	.7
22		1.60	1.00	.60	.60	.75	.7
23	0.65	1.20	.90	.60	.60	.80	.7
24	.65	1.10	.90	.65	.60	.80	.7
25	.65	1.00	1.00	.65	.60	.85	.8
26	.70	.95	1.00	.65	.60	.85	.8
27	.80	.95	.90	.70	.60	.85	1.0
28	.80	.95	.90	.65	.60	.85	1.0
29	2.60	.80	.90	.70	.60	.90	1.0
30	1.20	.80	.90	.70	.60	.90	1.0
31		.80	.85		.60		1.0

BLACK WATER CREEK NEAR JASPER, ALA.

This station was established as a bench-mark station. It is located 100 yards below the dam at Camack's mill, 6 miles north of Jasper, Ala. Discharge measurements are made from the single-span iron highway bridge with short trestle approaches at either end. The initial point for soundings is the end of the bridge at the right bank, upstream side. The channel is straight for about 200 feet above and 500 feet below the station. The current is swift. Both banks are wooded, and liable to overflow under the trestle approaches. The bed of the stream is rocky and permanent. There is but one channel at all stages, broken during high water by the piers and trestle work of the bridge. The bench mark is the top of the upstream eyebar, 49 feet from the right-bank end of the bridge. Its elevation is 20.00 feet above the gage datum.

Discharge measurements of Black Water Creek near Jasper, Ala., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Foot per sec.*	*Feet.*	*Second-feet.*
May 24	J. M. Giles	42	35.6	0.63	1.10	22.5
August 9	do	41	40.0	.97	1.27	39
October 25[a]	do	3.5	2.3	.91	.75	2.1

[a] Mill not running, water being stored in pond.

BLACK WARRIOR RIVER (LOCUST FORK) AT PALOS, ALA.

Locust Fork of Black Warrior River rises in Blount County, Ala., and, flowing in a southwesterly course, enters Black Warrior River a short distance above Wilmington, Ala. Its drainage basin is hilly, and only a small part of its area is in cultivation. Palos station was established November 26, 1901, by R. C. McCalla, United States assistant engineer, who furnishes the daily gage heights to the United States Geological Survey. It is maintained by the United States Engineer Corps. The gage is a 4 by 8 inch timber, on the right bank of the river, just below the Kansas City, Memphis and Birmingham Railroad bridge. One section follows the slope of the bank from low water to a tree on top of the bank, and from there up a vertical section is fastened to the tree. The slope is 17 feet in elevation, measured vertically, and the vertical section of the rod is 15 feet. The rod is graduated to feet and tenths, with copper figures at the 5-foot points and roundhead tacks at intermediate foot marks. The total height is 32 feet. The datum of gage (about 251.71 feet above Mobile datum) is supposed to be extreme low water. High water, April, 1900, was about 37 feet.

Measurements are made from the Drennan Bridge, which is about a quarter of a mile below the Kansas City, Memphis and Birmingham Railroad bridge. The Drennan Bridge is the property of the Drennan Coal Mining Company. It is a mining railroad bridge, having width for a double-track tramway of 3 feet gage. One track is laid and in operation. The bridge has two iron spans of 100 feet each and trestle approaches at both ends.

Low-water measurements are made by wading at a shoal one-third mile below the bridge. The initial point for soundings is the left-bank end of the iron bridge on the downstream side. The channel is curved for 1,500 feet above the station and is straight for 3,000 feet below. At low water the channel is 180 feet wide. There is a ledge of rock about 200 feet below the station with about 3 feet fall. Both banks are high and wooded. The right bank overflows at flood stages, but only under the approach to the bridge. The bed is mainly of rock and is permanent.

Bench mark No. 1 is the top of the crossbeam at a point 80 feet from the left end of the bridge on the downstream side. Its elevation is 46.70 feet above the surface of the water, less the reading of the gage. It was established by measuring down to water surface with a steel tape. Bench mark No. 2 is a copper plug in a water-oak tree on the right hand, 20 feet downstream from the gage. Its elevation is 21.68 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Black Warrior River (Locust Fork) at Palos, Ala., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet.*
March 7 [a]	J. M. Giles	172	1,937	3.85	4.75	7,450
March 14 [a]	do	168	1,735	3.08	3.55	5,342
May 20 [a]	do	156	1,358	1.58	1.75	2,148
June 16 [a]	do	130	1,065	.40	.62	431
June 16 [a]	do	130	1,041	.39	.62	404
July 18 [b]	do	96	249	.91	.40	228
August 28 [b]	do	77	195	.43	.13	84
August 28 [c]	do	100	246	.38	.13	93
September 26 [d]	do	88	93	.50	.02	47
1904.						
January 18 [b]	J. M. Giles	93	243	.62	.38	151
March 24 [a]	M. R. and W. E. Hall.	156	1,305	1.28	1.58	1,680
May 23 [b]	J. M. Giles	82	197	.43	.16	86
May 23 [b]	do	82	204	.45	.16	91
August 8 [a]	do	152	1,225	.94	1.27	1,156
August 8 [b]	do	178	496	2.28	1.25	1,132
October 24 [e]	do	90	74	.32	— .04	24

[a] Drennan bridge.
[b] Frisco System Railroad bridge.
[c] Boat below Frisco bridge.
[d] Wading, one-third mile below Drennan Bridge.
[e] Wading, one-half mile below Drennan Bridge.

Mean daily gage height, in feet, of Black Warrior River (Locust Fork) at Palos, Ala., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.2	0.6	0.7	1.2	0.7	0.7	1.4	0.4	0.3	0.0	0.0	0.2
2	.2	.6	.7	1.2	.7	.8	.9	.4	.3	.0	.0	.3
3	.2	.5	.6	1.1	.6	.7	.5	.7	.3	.0	.2	.4
4	.1	.5	.6	1.1	.6	.5	.7	.6	.2	.0	.4	.6
5	.1	.5	.6	1.0	.5	.4	.5	1.0	.2	.0	.4	.1
6	.1	.5	.6	.9	.5	.4	.3	1.4	.2	.0	.3	1.4
7	.1	.6	1.9	1.2	.4	.3	.6	1.6	.2	.4	.2	1.3
8	.1	1.1	2.2	2.1	.7	.3	2.1	1.3	.1	.3	.2	1.1
9	.1	1.6	1.9	2.5	.7	.3	1.3	1.0	.1	.2	.2	1.9
10	.2	1.4	1.5	2.1	.6	.2	1.0	.8	.1	.1	.1	.9
11	.2	1.5	1.3	1.7	.7	.2	.8	1.3	.1	.1	.1	.8
12	.2	1.3	1.3	1.4	.6	.2	1.1	2.5	.1	.0	.1	.7
13	.2	1.3	1.3	1.3	.5	.2	1.2	2.1	.1	.0	.1	.7
14	.2	1.2	2.2	1.1	.4	.1	1.2	1.6	.0	.0	.1	.7
15	.2	1.0	5.0	1.0	.4	.1	.8	1.2	.0	.0	.1	.6
16	.2	.8	2.9	.9	.3	.1	.6	1.0	.0	.0	.1	.6
17	.3	.8	2.0	.9	.3	.0	.5	1.3	.0	.0	.1	.6
18	.4	.7	1.7	.9	.3	.0	.4	.9	.0	.0	.1	.5
19	.4	.7	1.5	.9	.2	.0	.4	.8	.0	.0	.1	.5
20	.4	.8	1.3	.8	.2	.0	.3	.6	.0	.0	.1	.5
21	.4	.8	1.2	.8	.2	.0	.3	.5	.0	.0	.1	.5
22	.6	.9	1.1	.8	.2	.0	.2	.4	.0	.0	.1	.4
23	1.3	.9	1.1	.8	.2	.0	.4	.4	.0	.0	.3	.4
24	2.3	.9	1.5	.7	.2	.0	.3	.4	.0	.0	.3	.4
25	1.1	.9	1.5	.7	.2	.6	.3	.3	.0	.0	.2	.8
26	.9	.8	1.3	.8	.2	.4	.3	.3	.0	.0	.2	.9
27	.8	.8	1.4	1.2	.1	.2	.4	1.0	.0	.0	.2	1.1
28	.7	.8	1.7	1.1	.1	.1	.4	.7	.0	.0	.2	2.9
29	.7	.7	1.6	.9	.1	.4	.5	1.0	.0	.0	.2	2.5
30	.6	.....	1.4	.8	.2	1.8	.3	.7	.0	.0	.2	1.7
31	.6	.....	1.3	.....	.5	.....	.2	.5	.....	.0	.....	1.3

Rating table for Black Warrior River (Locust Fork) at Palos, Ala., from January 1 to December 1, 1904.

Gage height.	Discharge.	Gage height	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet*	*Second-feet*	*Feet*	*Second-feet.*	*Feet.*	*Second-feet.*
.00	34	0.90	690	1.80	2,020	3.40	4,940
.10	67	1.00	810	1.90	2,190	3.60	5,320
.20	110	1.10	935	2.00	2,360	3.80	5,700
.30	165	1.20	1,070	2.20	2,710	4.00	6,100
.40	230	1.30	1,210	2.40	3,070	4.20	6,500
.50	305	1.40	1,360	2.60	3,430	4.40	6,900
.60	390	1.50	1,515	2.80	3,800	4.60	7,300
.70	480	1.60	1,680	3.00	4,180	4.80	7,700
.80	580	1.70	1,850	3.20	4,560	5.00	8,100

The above table is based upon twenty-one discharge measurements made during 1902, 1903, and 1904. It is well defined between gage heights −0.1 foot and 5 feet.

Estimated monthly discharge of Black Warrior River (Locust Fork) at Palos, Ala., for 1904.

[Drainage area, 1,020 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	2,890	67	356	0.349	0.402
February	1,680	305	705	.691	.745
March	8,100	390	1,649	1.62	1.87
April	3,250	480	1,032	1.01	1.13
May	480	67	244	.239	.276
June	2,020	34	225	.221	.247
July	2,530	110	511	.501	.578
August	3,250	165	818	.802	.925
September	165	34	63.8	.063	.070
October	230	34	49.1	.048	.055
November	230	34	99.8	.098	.109
December	3,990	67	805	.789	.910
The year	8,100	34	546	.536	7.32

MISCELLANEOUS MEASUREMENTS IN MOBILE RIVER DRAINAGE BASIN.

The following is a list of miscellaneous discharge measurements made in Mobile River drainage basin during 1904:

Pinelog Creek near Cash, Ga.—This stream flows into Sallacoa Creek, a tributary of Coosawattee River. A measurement was made May 5 at Butler's bridge, about 1 mile above the mouth, near Cash. The bench mark is the top of the downstream end of the cross timber on first bent from the left bank, 17.00 feet above the datum of the gage.

Width, 54 feet; area, 150 square feet; mean velocity, 0.27 foot per second; gage height, 2.80 feet; discharge, 41 second-feet.

Sallacoa Creek near Cash, Ga.—This stream is a tributary of Coosawattee River. A measurement was made May 5 at Covington's bridge, about 4 miles above the mouth of Pinelog Creek and 4 miles east of Cash, Ga. The bench mark is the upstream end of the top of cross timber over the first bent from the left bank, 16.00 feet above the datum of the gage.

Width, 42 feet; area, 164 square feet; mean velocity, 0.15 foot per second; gage height, 2.60 feet; discharge, 24 second-feet.

Jack River near Alaculsy, Ga.—A measurement was made October 5 just above the falls, about 5 miles above the mouth of the river and 23 miles from Blue Ridge, Ga.

Width, 7 feet; area, 7 square feet; mean velocity, 1.86 feet per second; discharge, 13 second-feet.

Oothcaloga Creek near Calhoun, Ga.—This stream is a tributary of Oostanaula River. A measurement was made May 6 at a bridge about 1 mile from the mouth of the creek and 1 mile west of Calhoun. The bench mark is the downstream end of the top of cross timber on middle bent, 16.00 feet above the datum of the gage.

Width, 45 feet; area, 50 square feet; mean velocity, 0.64 foot per second; gage height, 2.15 feet; discharge, 32 second-feet.

Connasauga River near Resaca, Ga.—This stream is a tributary of Oostanaula River. A measurement was made November 25 from a boat at Fite's ferry, 2 miles from Resaca, Ga. The bench mark is a small nail in a large leaning willow tree on the left bank, about 200 feet below the ferry, 5.00 feet above the datum of the gage.

Width, 130 feet; area, 219 square feet; mean velocity, 0.74 foot per second; gage height, 2.65 feet; discharge, 163 second-feet.

Etowah River near Kingston, Ga.—Measurements were made at Hardin's bridge, 4 miles south of Kingston, Ga., as follows:

January 24: Width, 188 feet; area, 1,178 square feet; mean velocity, 1.60 feet per second; gage height, 3.45 feet; discharge, 1,894 second-feet.

April 14: Width, 188 feet; area, 1,154 square feet; mean velocity, 1.21 feet per second; gage height, 3.27 feet; discharge, 1,401 second-feet.

July 29: Width, 185 feet; area, 1,007 square feet; mean velocity, 0.62 foot per second; gage height, 2.56 feet; discharge, 625 second-feet.

A 5-foot section of gage rod is fastened to a tree on the left bank.

Etowah River near Canton, Ga.—A measurement was made July 27 at Field's bridge, about 6 miles below Canton. The bench mark is a chisel cut and white paint mark at intermediate post, the second floor beam of the main span from the left end of the bridge, downstream side, 36.00 feet above the datum of the gage.

Width, 89 feet; area, 307 square feet; mean velocity, 1.05 feet per second; gage height, 2.67 feet; discharge, 322 second-feet.

Cave Spring at Cavespring, Ga.—This spring is tributary to Little Cedar Creek. A measurement was made January 21 at the footbridge at Cave Spring. The water surface was 16½ inches below the upstream side of the bridge floor, 6 inches from the right end of the bridge.

Width, 13 feet; area, 5.6 square feet; mean velocity, 0.94 foot per second; discharge, 5.3 second-feet.

Little Cedar River near Cavespring, Ga.—This stream enters Big Cedar Creek about 2 miles north of Cavespring, Ga. A measurement was made September 28 from the bridge near Cavespring. The bench mark is the top of the first floor beam from the right bank, downstream end, 9.00 feet above the datum of the gage.

Width, 30 feet; area, 18 square feet; mean velocity, 1.00 foot per second; gage height, 1.27 feet; discharge, 18 second-feet.

Big Cedar Creek near Cavespring, Ga.—This stream enters Coosa River about 6 miles northwest of Cavespring. Measurements were made at the bridge 2½ miles northeast of Cavespring. The bench mark is the top of the second iron floor beam from the right end of the bridge, upstream side, 17.00 feet above the datum of the gage.

January 21: Width, 62 feet; area, 207 square feet; mean velocity, 0.37 foot per second; gage height, 3.13 feet; discharge, 78 second-feet.

September 28: Width, 67 feet; area, 177 square feet; mean velocity, 0.29 foot per second; gage height, 3.00 feet; discharge, 51 second-feet.

Hatchet Creek near Goodwater, Ala.—This stream enters Coosa River about 10 miles east of Clanton, Ala. A measurement was made October 17 by wading 200 yards below bridge on the road to Hanover, Ala., 8 miles from Goodwater, Ala. The bench mark is the downstream end of the first floor beam from the left bank, 21.00 feet above the datum of the gage.

Width, 26 feet; area, 19 square feet; mean velocity, 0.96 foot per second; gage height, 1.05 feet; discharge, 18 second-feet.

Tallapoosa River near Tallapoosa, Ga.—A measurement was made March 9 from the wooden bridge near the Southern Railway and one-half mile below Bentley's dam, below the mouth of Walkers Creek. The bench mark is the top of the upper end of the floor beam on top of wooden pier, 106 feet from the initial point for soundings, 25.00 feet above the datum of the gage.

Width, 89 feet; area, 517 square feet; mean velocity, 0.74 foot per second; gage height, 6.25 feet; discharge, 381 second-feet.

Tallapoosa River near Heflin, Ala.—A measurement was made September 23 from Ross's bridge near Heflin, Ala. The bench mark is three tacks in first beam from the left bank, downstream side, 17.00 feet above the datum of the gage.

Width, 90 feet; area, 245 square feet; mean velocity, 0.77 foot per second; gage height, 2.22 feet, discharge, 189 second-feet.

Cedar Creek near Wedowee, Ala.—A measurement was made September 24 at the bridge 12 miles north of Wedowee. The bench mark is bolt which holds the bridge to maple tree on the left bank, upstream side, 7.00 feet above the datum of the gage.

Width, 25 feet; area, 42 square feet; mean velocity, 0.53 foot per second; gage height, 1.25 feet; discharge, 22 second-feet.

Hillabee Creek near Alexander City, Ala.—A gaging station was for a while maintained on this tributary of Tallapoosa River; the gage height below is from the old gage. A measurement made October 14 gave the following results:

Width, 87 feet; area, 96 square feet; mean velocity, 0.53 foot per second; gage height, 0.73 foot; discharge, 51 second-feet.

Tallapoosa River at Milstead, Ala.—A measurement was made April 14 at the old gaging station on Tallapoosa River at Milstead, which was abandoned April 30, 1903.

Width, 230 feet; area, 1,587 square feet; mean velocity, 2.44 feet per second; gage height, 2.93 feet; discharge, 3,871 second-feet.

Blackwater Creek near Jasper, Ala.—This stream is a tributary of Mulberry Fork of Black Warrior River. A measurement was made May 24 from the wagon bridge about 5 miles below Carmack's mill, near Jasper, Ala. The bench mark is the top of the downstream end of the floor beam 34 feet from the initial point for soundings, 36.00 feet above the datum of the gage.

Width, 34 feet; area, 41 square feet; mean velocity, 0.42 foot per second; gage height, 1.40 feet, discharge, 17 second-feet.

East Cahaba River near Birmingham, Ala.—A measurement was made August 6 from the foot log at the ford on the road to Columbiana, 10 miles from Birmingham. The bench mark is two copper nails in the downstream side of an ash tree on the left bank, 50 feet below the ford, 8.00 feet above the datum of the gage.

Width, 34 feet; area, 40 square feet; mean velocity, 1.67 feet per second; gage height, 2.00 feet; discharge, 66 second-feet.

East Cahaba River near Bridgeton, Ala.—A measurement was made August 6 at the ford below Deshazo's mill near Bridgeton.

Width, 49 feet; area, 57 square feet; mean velocity, 1.37 feet per second; discharge, 79 second-feet.

PEARL RIVER DRAINAGE BASIN.

Pearl River rises in the eastern part of Mississippi. It flows south into Lake Borgne, an arm of the Gulf of Mexico, forming part of the boundary between Louisiana and Mississippi. The United States Geological Survey maintains one station on this river. It is located at Jackson, Miss.

PEARL RIVER AT JACKSON, MISS.

This station was established June 24, 1901, by K. T. Thomas. It is located 2 miles from the Union station at Jackson, Miss., one-eighth mile above the Alabama and Vicksburg Railroad, and two blocks east from the end of the South State street car line. The chain gage is fastened to the downstream side of the bridge at a point 130 feet from the initial point for soundings. The length of the chain from the end of the weight to the marker is 41.91 feet. The gage is read once each day by James Hurst. Discharge measurements are made from the single-span highway bridge and from an approach of 680 feet of iron trestle on the left bank. The initial point for soundings is the end of

the bridge on the right bank. The channel makes a 90° curve about 200 feet above the bridge. It is nearly straight for about one-fourth mile below the bridge. The right bank is high and rocky and does not overflow. The left bank is of cleared ground and overflows at about 20 feet gage height. The width of the stream at low stages is about 130 feet and at flood stages about 900 feet. The bed is of sand and gravel and is shifting. The current velocity is moderate, but is not well distributed, and is broken by an old pier and some short piles under the bridge. At low stages the discharge can be measured by wading about one-fourth mile above the bridge. The bench mark is the downstream end of the top of the iron floor beam, 120 feet from the right-bank end of the bridge. Its elevation is 39.00 feet above gage datum. The elevation of the bridge floor at the same point is 40.15 feet above gage datum.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Pearl River at Jackson, Miss., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Square feet.*	*Feet per sec.*	*Feet.*	*Second-feet*
March 10	J. M. Giles		7,581	2.11	24.00	16,050
July 13	do		645	2.09	4.15	1,348
July 14	do		826	2.40	5.37	1,988
September 24	do		276	.46	.80	128
September 24	do		267	.53	.78	142
1904.						
January 15	J. M. Giles	107	408	.88	1.82	359
February 26	J. M. Giles and E. C. Murphy.	114	529	1.26	2.49	666
August 12	J. M. Giles	148	1,398	2.48	8.20	3,463
August 12	do	148	1,281	2.82	8.26	3,617
October 28	do	65	238	.35	.30	84
October 28[a]	do	35	72	1.12	.30	73

[a] From boat at different section.

Mean daily gage height, in feet, of Pearl River at Jackson, Miss., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.3	2.0	2.2	8.3	2.0	1.0	2.0	4.4	2.3	1.6	0.3	0.9
2	1.3	1.9	2.2	8.0	1.9	1.0	1.8	4.2	2.1	1.5	.3	1.0
3	1.4	1.9	2.3	7.6	1.8	1.0	1.4	3.8	2.0	1.3	.5	.8
4	1.4	2.0	2.2	6.4	1.8	1.0	1.3	3.4	1.8	1.2	.5	1.0
5	1.4	2.1	2.3	6.9	2.0	1.0	1.4	3.0	1.5	1.1	.4	1.0
6	1.4	2.3	3.9	5.5	2.4	1.1	1.4	2.9	1.5	1.0	.4	1.0
7	1.4	2.3	4.2	5.4	2.7	1.1	1.5	3.1	1.6	1.0	.5	1.3
8	1.5	2.4	4.5	9.8	2.9	1.0	2.1	3.2	1.5	.9	.4	1.4
9	1.5	2.6	4.6	10.9	3.2	1.0	2.0	3.8	1.4	.9	.4	1.4
10	1.4	4.3	3.9	10.9	3.4	1.1	1.7	5.8	1.4	.8	.5	1.4
11	1.4	5.5	3.8	11.1	2.9	1.2	2.5	6.8	1.4	.8	.5	1.4
12	1.5	6.5	3.7	10.2	2.6	1.4	4.4	8.1	1.3	.8	.5	1.5
13	1.6	7.4	3.6	8.6	2.3	1.5	7.1	7.1	1.3	.7	.5	1.5
14	1.8	6.5	3.7	8.0	1.9	1.7	4.8	6.6	1.3	.6	.5	1.5
15	1.8	5.6	3.5	7.5	1.8	1.7	5.0	6.2	1.2	.6	.5	1.4
16	1.8	5.1	3.2	7.1	1.7	1.6	4.7	5.9	1.1	.5	.5	1.4
17	1.9	4.6	3.1	6.7	1.6	1.5	4.5	5.7	1.1	.5	.5	1.3
18	1.8	4.2	2.7	5.0	1.6	1.3	4.1	5.5	1.1	.5	.5	1.3
19	1.8	3.8	2.6	4.3	1.5	1.3	4.2	5.2	1.0	.5	.5	1.2
20	1.7	3.5	2.7	3.7	1.5	1.2	5.2	4.9	1.0	.4	.5	1.2
21	1.7	3.2	7.3	3.5	1.4	1.2	4.9	4.6	1.0	.4	.7	1.1
22	1.8	3.0	6.7	3.1	1.3	1.1	3.8	4.4	1.0	.4	.8	1.1
23	2.0	2.8	7.0	2.9	1.2	1.1	3.6	4.2	1.0	.4	.7	1.0
24	1.9	2.6	6.7	2.8	1.2	1.1	3.1	3.8	1.3	.4	.6	1.0
25	1.7	2.5	6.2	2.6	1.2	.9	2.8	3.6	1.4	.4	.6	1.0
26	1.7	2.5	5.6	2.4	1.1	.8	2.7	3.3	1.2	.3	.6	1.1
27	1.8	2.4	6.8	2.3	1.1	.8	2.6	2.9	1.2	.3	.5	1.7
28	1.9	2.3	9.4	2.2	1.1	.8	2.6	2.8	1.3	.3	.5	1.9
29	2.0	2.2	9.9	2.1	1.1	1.2	2.7	2.7	1.4	.3	.6	1.5
30	2.0	.....	9.5	2.0	1.1	3.6	4.0	2.9	1.6	.3	.8	1.8
31	2.0	.....	8.7	.....	1.1	.....	4.5	2.7	.....	.3	.....	2.4

Rating table for Pearl River at Jackson, Miss., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.30	80	1.50	262	3.40	982	5.80	2,200
.40	88	1.60	288	3.60	1,078	6.00	2,310
.50	97	1.70	316	3.80	1,174	6.50	2,585
.60	108	1.80	345	4.00	1,272	7.00	2,860
.70	120	1.90	375	4.20	1,370	7.50	3,135
.80	133	2.00	407	4.40	1,470	8.00	3,435
.90	147	2.20	475	4.60	1,570	8.50	3,735
1.00	162	2.40	548	4.80	1,670	9.00	4,035
1.10	178	2.60	627	5.00	1,770	9.50	4,335
1.20	196	2.80	710	5.20	1,870	10.00	4,635
1.30	216	3.00	797	5.40	1,980	10.50	4,935
1.40	238	3.20	888	5.60	2,090	11.00	5,235

The preceding table is based upon fourteen discharge measurements made during 1901–1904. It is well defined between gage heights 0.30 foot and 8.30 feet. The table has been extended beyond these limits.

Estimated monthly discharge of Pearl River at Jackson, Miss., for 1904.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
January	407	216	310
February	3,080	375	1,059
March	4,575	475	1,747
April	5,295	407	2,372
May	982	178	382
June	1,078	133	224
July	2,915	216	972
August	3,495	668	1,518
September	511	162	242
October	288	80	125
November	133	80	100
December	548	133	222
The year	5,295	80	773

MINOR EASTERN GULF OF MEXICO DRAINAGE BASINS.

MISCELLANEOUS MEASUREMENTS.

Conecuh River near River Falls, Ala.—A measurement was made May 24 at a bridge 8 miles above the regular gaging station on Conecuh River at Beck, Ala. The water surface was 46.69 feet below the top of the downstream end of second floor beam from the left end of the bridge.

Width, 120 feet; area, 372 square feet; mean velocity, 1.05 feet per second; discharge, 391 second-feet.

Patsaliga Creek near Gantt, Ala.—This stream is practically the North Fork of Conecuh River, entering from the right about 4 miles north of Andalusia, Ala. A measurement was made June 24 at Parker Bridge, near Gantt. The water surface was 28.07 feet below the head of a nail driven into the top of the downstream end of the wooden floor beam under the middle of the truss.

Width, 65 feet; area, 48 square feet; mean velocity, 1.89 feet per second; discharge, 91 second-feet.

Yellow River near Oak Grove, Fla.—A measurement was made June 23 at Richburg Bridge, about 7 miles east of Laurel Hill, Fla. The bench mark is the top of the upstream end of the first floor beam from the left pier of the bridge, 20.00 feet above the datum of the gage.

Width, 107 feet; area, 190 square feet; mean velocity, 1.20 feet per second; gage height, 2.19 feet; discharge, 227 second-feet.

Choctawhatchee River near Elba Junction, Ala.—A measurement was made September 24 from the Atlantic Coast Line Railway bridge, near Elba Junction. The water surface was 35.85 feet below the top of the first floor beam from the right bank.

Width, 95 feet; area, 471 square feet; mean velocity, 0.26 foot per second; discharge, 124 second-feet.

Choctawhatchee River near Newton, Ala.—A measurement was made September 24 at the wagon bridge 1 mile west of Newton and 2 miles below the gaging made the same day near Elba Junction. The water surface was 36.70 feet below the top of reinforcing plate at the bottom of the fourth intermediate post from the left bank, downstream side.

Width, 55 feet; area, 99 square feet; mean velocity, 1.27 feet per second; discharge, 125 second-feet.

Choctawhatchee River near Bellwood, Ala.—A measurement was made June 20 from the wagon bridge 2 miles from Bellwood. The water surface was 20.45 feet below the top of the downstream lower chord, at a point 1 foot to the right of the first intermediate post from the left bank.

Width, 151 feet; area, 456 square feet; mean velocity, 0.90 foot per second; discharge, 411 second-feet.

Suwanee River at railway bridge, near Suwanee, Fla.—Measurements were made from the Atlantic Coast Line Railway bridge near Suwanee, Fla. The bench mark is the top of the downstream end of the second floor beam from the right bank, 45.00 feet above the datum of the gage.

December 20—Width, 79 feet; area, 397 square feet; mean velocity, 0.74 foot per second; gage height, 2.85 feet; discharge, 295 second-feet.

December 20—Width, 79 feet; area, 394 square feet; mean velocity, 0.73 foot per second; gage height, 2.85 feet; discharge, 290 second-feet.

Suwanee River at wagon bridge, near Suwanee, Fla.—A measurement was made December 21 from the wagon bridge at Suwanee Sulphur Spring. The bench mark is a chisel mark on the first intermediate post from the right bank, 6 feet above the top of the floor beam, 41.00 feet above the datum of the gage.

Width, 89 feet; area, 249 square feet; mean velocity, 0.95 foot per second; gage height, 1.57 feet; discharge, 237 second-feet.

Suwanee River near Ellaville, Fla.—A measurement was made December 22 from the Seaboard Air Line Railway bridge. The bench mark is the downstream end of the first floor beam from the left bank, 37.00 feet above the datum of the gage.

Width, 231 feet; area, 1,798 square feet; mean velocity, 1.01 feet per second; gage height, 1.41 feet; discharge 1,813 second-feet.

Santa Fe River near High Springs, Fla.—This stream enters Suwanee River from the left about 30 miles above its mouth. A measure-

ment was made December 22 at the wagon bridge, just above the Atlantic Coast Line Railroad bridge. The bench mark is the top of the downstream end of the cap of the first bent from the left bank, 17.00 feet above the datum of the gage.

Width, 130 feet; area, 996 square feet; mean velocity, 0.54 foot per second; gage height, 1.60 feet; discharge, 537 second-feet.

Withlacoochee River at Dunnellon, Fla.—A measurement was made December 24 from the new iron wagon bridge, one-fourth mile from Dunnellon, Fla.:

Width, 82 feet; area, 1,003 square feet; mean velocity, 1.27 feet per second; discharge, 1,270 second-feet. The water surface was 14.05 feet below the top of the downstream right-bank pier.

Blue Run near Dunnellon, Fla.—This stream is tributary to Withlacoochee River. A measurement was made December 24 from the wagon bridge, three-fourths mile east of Dunnellon:

Width, 53 feet; area, 422 square feet; mean velocity, 1.70 feet per second; discharge, 716 second-feet. The water surface was 4.45 feet below the top of the cap of the right bent, downstream side of the bridge.

INDEX.

Alabama River at— Page.
Selma, Ala.:
description 127–128
discharge 128
discharge, monthly 130
gage heights 129
rating table 129
Alaculsy, Ga.
Jack River near:
description 174
discharge 174
Albany, Ga.
Blue Spring near:
description 120
discharge 120
Flint River at:
description 109–111
discharge 111
discharge, monthly 113
gage heights 112
rating table 113
Kinchafoonee Creek near:
description 115–116
discharge 116
Muckalee Creek near:
description 114–115
discharge 115
Alcovy River near—
Covington, Ga.:
description 69–70
discharge 70
discharge, monthly 72
gage heights 71
rating table 71
Newton Factory, Ga.:
description 89
discharge 89
Alexander City, Ala.
Hillabee Creek near:
description 176
discharge 176
Alston, S. C.
Broad River (of the Carolinas) at:
description 28–29
discharge 29
discharge, monthly 31
gage heights 30
rating table 30
Altamaha River drainage basin:
description 59–60
Apalachee River near—
Buckhead, Ga.:
description 72–73
discharge 73
discharge, monthly 75
Apalachee River near—Continued. Page.
Buckhead, Ga.—Continued.
gage heights 74
rating table 74
Apalachicola River drainage basin:
description 90–91
Armour, Ga.
Peachtree Creek at:
description 118
discharge 118
Peachtree Creek (North Fork) near:
description 117
discharge 117
Peavine Creek near:
description 118
discharge 118
Augusta, Ga.
Savannah River at:
description 42–43
discharge 43
discharge, monthly 45
gage heights 44
rating table 45
Austell, Ga.
Sweetwater Creek near:
description 103, 119
discharge 104, 119
gage heights 104
Beaverdam Creek near—
Clarksville, Ga:
description 116
discharge 116
Greensboro, Ga.:
description 89–90
discharge 90
Beck, Ala.
Conecuh River at:
description 125–126
discharge 126
gage heights 127
Bellwood, Ala.
Choctawhatchee River near:
description 181
discharge 181
Belmont, N. C.
Catawba River near:
description 36
discharge 36
Catawba River (South Fork) near:
description 36
discharge 36
Big Cedar Creek near—
Cavespring, Ga.:
description 176
discharge 176

Big Potato Creek near— Page.
Thomaston, Ga.:
description 114, 120
discharge 114, 120
Birmingham, Ala.
East Cahaba River near:
description 177
discharge 177
Black Warrior River at and near—
Cordova, Ala.:
description 163–164
discharge 164
discharge, monthly 166
gage heights 165
rating table 166
Tuscaloosa, Ala.:
description 167
discharge 168
gage heights 168
Black Warrior River (Locust Fork) at—
Palos, Ala.:
description 171–172
discharge 172
discharge, monthly 174
gage heights 173
rating table 173
Black Water Creek near—
Jasper, Ala.:
description 170, 177
discharge 171, 177
Blackshear, Ga.
Hurricane Creek near:
description 90
discharge 90
Blue Run near—
Dunnellon, Fla.:
description 182
discharge 182
Blue Spring near—
Albany, Ga.:
description 120
discharge 120
Bridgeton, Ala.
East Cahaba River near:
description 177
discharge 177
Broad River (of the Carolinas) at—
Alston, S. C.:
description 28–29
discharge 29
discharge, monthly 31
gage heights 30
rating table 30
Broad River (of Georgia) near—
Carlton, Ga.:
description 50
discharge 51
discharge, monthly 52
gage heights 51
rating table 52
Broad River (South Fork) near—
Carlton, Ga.:
description 53, 54
discharge 53, 54
Comer, Ga.:
description 53
discharge 53
Brookwood, Ga. Page.
Peachtree Creek near:
description 119
discharge 119
Buckhead, Ga.
Apalachee River near:
description 72–73
discharge 73
discharge, monthly 75
gage heights 74
rating table 74
Cahaba River at—
Centerville, Ala.:
description 157–158
discharge 158
discharge, monthly 160
gage heights 159
rating table 159
Calhoun, Ga.
Oothcaloga Creek near:
description 175
discharge 175
Calhoun, S. C.
Keowee River near:
description 75
discharge 76
Calhoun Falls, Ga.
Rocky River near:
description 49–50
discharge 50
Camden, S. C.
Wateree River near:
description 27–28
discharge 28
gage heights 28
Cannoochee River near—
Groveland, Ga.:
description 56–57
discharge 57
discharge, monthly 59
gage heights 58
rating table 58
Canton, Ga.
Etowah River at and near:
description 130–131, 175
discharge 131, 175
discharge, monthly 133
gage heights 132
rating table 132
Carlton, Ga.
Broad River (of Georgia) near:
description 50
discharge 51
discharge, monthly 52
gage heights 51
rating table 52
Broad River (South Fork) near:
description 53, 54
discharge 53, 54
Clouds Creek near:
description 54
discharge 54
Cartecay, Ga.
Cartecay River near:
description 142
discharge 142
gage heights 143

Cartecay River near— Page.
Cartecay, Ga.:
description 142
discharge..... 142
gage heights..... 143
Carters, Ga.
Coosawattee River at:
description 139
discharge 140
discharge, monthly 141
gage heights..... 140
rating table 141
Talking Rock Creek near:
description 144–145
discharge..... 145
Cash, Ga.
Pinelog Creek near:
description 174
discharge..... 174
Sallacoa Creek near:
description 174
discharge..... 174
Catawba, S. C.
Catawba River near:
description 20
discharge..... 21
discharge, monthly 22
gage heights..... 21
rating table 22
Catawba River near—
Belmont, N. C.:
description 36
discharge..... 36
Catawba, S. C.:
description 20
discharge..... 21
discharge, monthly..... 22
gage heights..... 21
rating table 22
Morganton, N. C.:
description 23
discharge..... 24
discharge, monthly..... 26
gage heights..... 25
rating table 25
Rock Hill, S. C.:
description 36
discharge..... 36
Catawba River (South Fork) near—
Belmont, N. C.:
description 36
discharge..... 36
Cave Spring at—
Cavespring, Ga.:
description 175
discharge..... 175
Cavespring, Ga.
Big Cedar Creek near
description 176
discharge..... 176
Cave Spring at:
description 175
discharge..... 175
Little Cedar Creek near:
description 175
discharge 175
Cedar Creek near— Page.
Wedowee, Ala.:
description 176
discharge..... 176
Centerville, Ala.
Cahaba River at:
description 157–158
discharge..... 158
discharge, monthly 160
gage heights 159
rating table 159
Chattahoochee River at and near—
Cornelia, Ga.:
description 91–92
discharge..... 92
Norcross, Ga.:
description 92–93
discharge..... 93
discharge, monthly 95
gage heights..... 94
rating table..... 94
Oakdale, Ga.:
description 95–96
discharge..... 96
discharge, monthly 98
gage heights..... 97
rating table..... 97
West Point, Ga.:
description 98–99
discharge..... 99
discharge, monthly 101
gage heights..... 100
rating table..... 100
Chauga River near—
Fort Madison, S. C.:
description 46
discharge..... 46
Choccolocco Creek near—
Jenifer, Ga.:
description 145
discharge..... 146
discharge, monthly 148
gage heights..... 147
rating table..... 147
Choctawhatchee River near—
Bellwood, Ala.:
description 181
discharge..... 181
Elba Junction, Ala.:
description 181
discharge..... 181
Geneva, Ala.:
description 121
discharge..... 122
gage heights..... 122
Newton, Ala.:
description 181
discharge..... 181
Choctawhatchee River drainage basin:
description 120–121
Clarksville, Ga.
Beaverdam Creek near:
description 116
discharge..... 116
Deep Creek near:
description 116
discharge..... 116

Clarksville, Ga.—Continued. Page.
Soque River near:
description 117
discharge..... 117
Clear Creek near—
Elk, Ala.:
description 169
discharge..... 169
gage heights..... 170
Clemson College, S. C.
Seneca River near:
description 46–47
discharge..... 47–48
discharge, monthly 49
gage heights..... 48
rating table 49
Clouds Creek near—
Carlton, Ga.:
description 54
discharge..... 54
Columbus, Ga.
Mulberry Creek near:
description 105
discharge..... 105
Columbus, Miss.
Tombigbee River near:
description 160–161
discharge..... 161
discharge, monthly 163
gage heights..... 162
rating table..... 162
Comer, Ga.
Broad River of Georgia (South Fork) near:
description 53
discharge..... 53
Concord, Ga.
Flint River near:
description 119
discharge..... 119
Conecuh River at and near—
Beck, Ala.:
description 125–126
discharge..... 126
gage heights..... 127
River Falls, Ala.:
description 180
discharge..... 180
Connasauga River near—
Resaca, Ga.:
description 175
discharge..... 175
Coosa River at—
Riverside, Ala.:
description 136
discharge..... 136
discharge, monthly..... 138
gage heights..... 137
rating table..... 137
Coosawattee River at—
Carters, Ga.:
description 139
discharge..... 140
discharge, monthly..... 141
gage heights..... 140
rating table..... 141
Cordova, Ala.
Black Warrior River near:
description 163–164

Cordova, Ala.—Continued. Page.
Black Warrior River near—Cont'd.
discharge..... 164
discharge, monthly..... 166
gage heights..... 165
rating table..... 166
Cornelia, Ga.
Chattahoochee River near:
description 91–92
discharge..... 92
Soque River near:
description 117
discharge..... 117
Covington, Ga.
Alcovy River near:
description 69–70
discharge..... 70
discharge, monthly..... 72
gage heights..... 71
rating table..... 71
Davisboro, Ga.
Williamsons Swamp Creek at:
description 54–55
discharge..... 56
gage heights..... 56
Deep Creek near—
Clarksville, Ga.:
description 116
discharge..... 116
Delta, S. C.
Tiger River at:
description 32
discharge..... 31
Demorest, Ga.
Hazel Creek near:
description 117
discharge..... 117
Soque River near:
description 101–102
discharge..... 102
discharge, monthly..... 103
gage heights..... 102
rating table 102
Double Bridges Creek at—
Geneva, Ala.:
description 122–123
discharge..... 123
gage heights..... 123
Dublin, Ga.
Oconee River at:
description 81–82
discharge..... 83
discharge, monthly..... 85
gage heights..... 84
rating table 84
Dunnellon, Fla.
Blue Run near:
description 181
discharge..... 181
Withlacoochee River at:
description 182
discharge..... 182
East Cahaba River near—
Birmingham, Ala.:
description 177
discharge..... 177
Bridgeton, Ala.:
description 177
discharge..... 177

Elba Junction, Ala. Page.
Choctawhatchee River near:
description 181
discharge 181
Elk, Ala.
Clear Creek near:
description 169
discharge 169
gage heights 170
Ellaville, Fla.
Suwanee River near:
description 181
discharge 181
Ellijay, Ga.
Ellijay River near:
description 143
discharge 144
Mountaintown Creek near:
description 144
discharge 144
Ellijay River near—
Ellijay, Ga.:
description 143
discharge 144
Enoree River near—
Whitmire, S. C.:
description 32
discharge 32
Escambia River drainage basin:
description 125
Etowah River at and near—
Canton, Ga.:
description 130–131, 175
discharge 131, 175
discharge, monthly 133
gage heights 132
rating table 132
Kingston, Ga.:
description 175
discharge 175
Rome, Ga.:
description 133–134
discharge 134
discharge, monthly 135
gage heights 135
rating table 135
Flint River at and near—
Albany, Ga.:
description 109–111
discharge 111
discharge, monthly 113
gage heights 112
rating table 113
Concord, Ga.:
description 119
discharge 119
Montezuma, Ga.:
description 119
discharge 119
Woodbury, Ga.:
description 105–106, 119
discharge 106, 119
discharge, monthly 109
gage heights 107
rating table 108
Flovilla, Ga. Page.
Ocmulgee River near:
description 63–64
discharge 64
discharge, monthly 66
gage heights 65
rating table 65
Fort Madison, S. C.
Chauga River near:
description 46
discharge 46
Gantt, Ala.
Patsaliga Creek near:
description 180
discharge 180
Geneva, Ala.
Choctawhatchee River near:
description 121
discharge 122
gage heights 122
Double Bridges Creek at:
description 122–123
discharge 123
gage heights 123
Goodwater, Ala.
Hatchet Creek near:
description 176
discharge 176
Greensboro, Ga.
Beaverdam Creek near:
discription 89–90
discharge 90
Oconee River near:
description 75–76
discharge 76
discharge, monthly 78
gage heights 77
rating table 77
Groveland, Ga.
Cannoochee River near:
description 56–57
discharge 57
discharge, monthly 59
gage heights 58
rating table 58
Hatchet Creek near—
Goodwater, Ala.:
description 176
discharge 176
Hazel Creek near—
Demorest, Ga.:
description 117
discharge 117
Heflin, Ala.
Tallapoosa River near:
description 152, 176
discharge 152, 176
High Springs, Fla.
Santa Fe River near:
description 181–182
discharge 182
Hillabee Creek near—
Alexander City, Ala.:
description 176
discharge 176

Horse Creek near— Page.
Lumber City, Ga.:
description ... 89
discharge ... 89
Hurricane Creek near—
Blackshear, Ga.:
description ... 90
discharge ... 90
Jack River near—
Alaculsy, Ga.:
description ... 174
discharge ... 174
Jackson, Ga.
South River near:
description ... 88
discharge ... 88
Yellow River near:
description ... 88
discharge ... 88
Jackson, Miss.
Pearl River at:
description ... 177–178
discharge ... 178
discharge, monthly ... 180
gage heights ... 179
rating table ... 179
Jasper, Ala.
Black Water Creek near:
description ... 170, 177
discharge ... 171, 177
Jenifer, Ga.
Choccolocco Creek near:
description ... 145
discharge ... 146
discharge, monthly ... 148
gage heights ... 147
rating table ... 147
John River near—
Morganton, N. C.:
description ... 26
discharge ... 27
Keowee River near—
Calhoun, S. C.:
description ... 53
discharge ... 53
Kinchafoonee Creek near—
Albany, Ga.:
description ... 115–116
discharge ... 116
Kingston, Ga.
Etowah River near:
description ... 175
discharge ... 175
Lithia Springs, Ga.
Sweetwater Creek near:
description ... 118
discharge ... 118
Lithonia, Ga.
Pole Bridge Creek near:
description ... 88
discharge ... 88, 89
South River near:
description ... 60, 61
discharge ... 61
discharge, monthly ... 63
gage heights ... 62
rating table ... 62
Little Cedar Creek near— Page.
Cavespring, Ga.:
description ... 175
discharge ... 175
Little Ocmulgee River at—
Wilcox, Ga.:
description ... 95
discharge ... 96
Little River near—
Milledgeville, Ga.:
description ... 80
discharge ... 81
Little Tallapoosa River near—
Wedowee, Ala.:
description ... 156, 157
discharge ... 157
Lumber City, Ga.
Horse Creek near:
description ... 89
discharge ... 89
Macon, Ga.
Ocmulgee River at:
description ... 66–67
discharge ... 67
discharge, monthly ... 68
gage heights ... 68
rating table ... 68
Madison, S. C.
Tugaloo River near:
description ... 38–40
discharge ... 40
discharge, monthly ... 42
gage heights ... 41
rating table ... 41
Milledgeville, Ga.
Little River near:
description ... 80
discharge ... 80
Oconee River at and near:
description ... 78–79, 82
discharge ... 79, 82
discharge, monthly ... 81
gage heights ... 81
rating table ... 81
Milstead, Ala.
Tallapoosa River at:
description ... 157
discharge ... 157
Mobile River drainage basin:
description ... 127
Montezuma, Ga.
Flint River near:
description ... 113
discharge ... 113
Morganton, N. C.
Catawba River near:
description ... 25
discharge ... 26
discharge, monthly ... 28
gage heights ... 25
rating table ... 25
John River near:
description ... 26
discharge ... 27
Mountaintown Creek near—
Ellijay, Ga.:
description ... 144
discharge ... 144

Muckalee Creek near— Page.
Albany, Ga.:
description 114–115
discharge..... 115
Mulberry Creek near—
Columbus, Ga.:
description 105
discharge..... 105
Newton, Ala.
Choctawhatchee River near:
description 181
discharge..... 181
Newton Factory, Ga.
Alcovy River near:
description 89
discharge..... 89
Nickajack, Ga.
Nickajack Creek near:
description 118
discharge..... 118
Nickajack Creek near—
Nickajack, Ga.:
description 118
discharge..... 118
Norcross, Ga.
Chattahoochee River near:
description 92–93
discharge..... 93
discharge, monthly 95
gage heights..... 94
rating table..... 94
Nottingham, Ala.
Talledega Creek at:
description 148
discharge..... 149
discharge, monthly 150
gage heights..... 149
rating table 150
Oak Grove, Fla.
Yellow River near:
description 180
discharge..... 180
Oakdale, Ga.
Chattahoochee River at:
description 95–96
discharge..... 96
discharge, monthly 98
gage heights..... 97
rating table 97
Ocmulgee River at and near—
Flovilla, Ga.:
description 63–64
discharge..... 64
discharge, monthly 66
gage heights..... 65
rating table 65
Macon, Ga.:
description 66–67
discharge..... 67
discharge, monthly 69
gage heights..... 68
rating table 68
Oconee River at and near—
Dublin, Ga.:
description 81–82
discharge..... 83
discharge, monthly 85
Oconee River at and near—Continued. Page.
Dublin, Ga.—Continued.
gage heights..... 84
rating table 84
Greensboro, Ga.:
description 75–76
discharge..... 76
discharge, monthly 78
gage heights..... 77
rating table 77
Milledgeville, Ga.:
description 78–79, 89
discharge..... 79–89
discharge, monthly 81
gage heights..... 80
rating table 80
Ogeechee River drainage basin:
description 54
Ohopee River near—
Reidsville, Ga.:
description 85–86
discharge..... 86
discharge, monthly 88
gage heights..... 87
rating table 87
Oostanaula River at—
Resaca, Ga.:
description 138–139
Oothcaloga Creek near—
Calhoun, Ga.:
description 175
discharge..... 175
Palos, Ala.
Black Warrior River (Locust Fork) at:
description 171–172
discharge..... 172
discharge, monthly 174
gage heights..... 173
rating table 173
Patsaliga Creek near—
Gantt, Ala.:
description 180
discharge..... 180
Pea River at—
Pera, Ala.:
description 123–124
discharge..... 124
gage heights..... 125
Peachtree Creek at and near—
Armour, Ga.:
description 118
discharge..... 118
Brookwood, Ga.:
description 118
discharge..... 118
Peachtree Creek (North Fork) near—
Armour, Ga.:
description 117
discharge..... 117
Pearl River at—
Jackson, Miss.:
description 177–178
discharge..... 178
discharge, monthly..... 180
gage heights..... 179
rating table..... 179
Pearl River drainage basin:
description 177

Peavine Creek near— Page.
Armour, Ga.:
description 118
discharge..... 118
Pera, Ala.
Pea River at:
description 123–124
discharge..... 124
gage heights..... 125
Pinelog Creek near—
Cash, Ga.:
description 174
discharge..... 174
Pole Bridge Creek near—
Lithonia, Ga.:
description 88
discharge..... 88, 89
Red Oak Creek near—
Woodbury, Ga.:
description 119–120
discharge..... 120
Reedy River near—
Waterloo, S. C.:
description 35
discharge..... 36
Reidsville, Ga.
Ohoopee River near:
description..... 85–86
discharge..... 86
discharge, monthly 88
gage heights..... 87
rating table 87
Resaca, Ga.
Connasauga River near:
description 175
discharge..... 175
Oostanaula River at:
description..... 138–139
River Falls, Ala.
Conecuh River near:
description 180
discharge..... 180
Riverside, Ga.
Coosa River at:
description..... 136
discharge..... 136
discharge, monthly 138
gage heights 137
rating table 137
Riverview, Ga.
White Oak Creek near:
description 119
discharge..... 119
Rock Hill, N. C.
Catawba River near:
description 56
discharge..... 36
Rocky River near—
Calhoun Falls, S. C.:
description 49–50
discharge..... 50
Rome, Ga.
Etowah River near:
description 133–134
discharge..... 134
discharge, monthly 135
gage heights..... 135
rating table 135
Rottenwood Creek near— Page.
Vinings, Ga.:
description 117
discharge..... 117
Sallacoa Creek near—
Cash, Ga.:
description 174
discharge..... 174
Saluda River near—
Waterloo, S. C.:
description 32–33, 36
discharge..... 33, 36
discharge, monthly 35
gage heights 34
rating table 34
Santa Fe River near—
High Springs, Fla.:
description 181–182
discharge..... 182
Santee River drainage basin:
description 17–19
Satilla River near—
Waycross, Ga.:
description 90
discharge..... 90
Savannah River at—
Augusta, Ga.:
description 42–43
discharge..... 43
discharge, monthly 45
gage heights..... 44
rating table 45
Savannah River drainage basin:
description 37
Selma, Ala.
Alabama River at:
description 127–128
discharge..... 128
discharge, monthly 130
gage heights..... 129
rating table 129
Seneca River near—
Clemson College, S. C.:
description..... 46–47
discharge..... 47–48
discharge, monthly 49
gage heights 48
rating table 49
Soque River near—
Clarksville, Ga.:
description..... 117
discharge..... 117
Cornelia, Ga.:
description..... 117
discharge..... 117
Demorest, Ga.:
description..... 101–102
discharge..... 102
discharge, monthly 103
gage heights 102
rating table 102
South River near—
Jackson, Ga.:
description..... 88
discharge..... 88
Lithonia, Ga.:
description..... 60, 61
discharge..... 61

South River near—Continued. Page.
Lithonia, Ga.—Continued.
discharge, monthly 63
gage heights 62
rating table 62
Sturdevant, Ala.
Tallapoosa River at:
description 153
discharge 154
discharge, monthly 156
gage heights 155
rating table 155
Sugar Creek at—
Wilcox, Ga.:
description 89
discharge 89
Suwanee, Fla.
Suwanee River near:
description 181
discharge 181
Suwanee River near—
Ellaville, Fla.:
description 181
discharge 181
Suwanee, Fla.:
description 181
discharge 181
Sweetwater Creek near—
Austell, Ga.:
description 103, 119
discharge 104, 119
gage heights 104
Lithia Springs, Ga.:
description 118
discharge 118
Talking Rock Creek near—
Carters, Ga.:
description 144–145
discharge 145
Talladega Creek at—
Nottingham, Ala.:
description 148
discharge 149
discharge, monthly 150
gage heights 149
rating table 150
Tallapoosa, Ga.
Tallapoosa River near:
description 150–151, 176
discharge 151, 152, 176
Tallapoosa River at and near—
Heflin, Ala.:
description 152, 176
discharge 152, 176
Milstead, Ala.:
description 177
discharge 177
Sturdevant, Ala.:
description 153
discharge 154
discharge, monthly 156
gage heights 155
rating table 155
Tallapoosa, Ga:
description 150–151, 176
discharge 151, 152, 176
Tallulah Falls, Ga. Page.
Tallulah River at:
description 37–38
discharge 38
discharge, monthly 39
gage heights 38
rating table 39
Tallulah River at—
Tallulah Falls, Ga.:
description 37–38
discharge 38
discharge, monthly 39
gage heights 38
rating table 39
Thomaston, Ga.
Big Potato Creek near:
description 114, 120
discharge 114, 120
Tiger Creek at—
Wiley, Ga.:
description 53
discharge 53
Tiger River at—
Delta, S. C.:
description 31
discharge 31
Tombigbee River near—
Columbus, Miss.:
description 160–161
discharge 161
discharge, monthly 163
gage heights 162
rating table 162
Tugaloo River near—
Madison, S. C.:
description 39–40
discharge 40
discharge, monthly 42
gage heights 41
rating table 41
Tuscaloosa, Ala.
Black Warrior River at:
description 167
discharge 168
gage heights 168
Vinings, Ga.
Rottenwood Creek near:
description 117
discharge 117
Warnersville, Ga.
White Oak Creek near:
description 119
discharge 119
Wateree River, near—
Camden, S. C.:
description 27–28
discharge 28
gage heights 28
Waterloo, S. C.
Reedy River near:
description 35
discharge 36
Saluda River near:
description 32–33, 36
discharge 33, 36
discharge, monthly 35

Waterloo, S. C.—Continued. Page.
Saluda River near—Continued.
gage heights 34
rating table 34
Waycross, Ga.
atilla River near:
description 90
discharge 90
Wedowee, Ala.
Cedar Creek near:
description 176
discharge 176
Little Tallapoosa River 3 miles north of:
description 156
discharge 157
Little Tallapoosa River 6 miles northwest of:
description 157
discharge 157
West Point, Ga.
Chattahoochee River at:
description 98–99
discharge 99
discharge, monthly 101
gage heights 100
rating table 100
White Oak Creek near—
Riverview, Ga.:
description 119
discharge 119
Warnersville, Ga.:
description 119
discharge 119
Whitmire, S. C.
Enoree River near:
description 32
discharge 32
Wilcox, Ga. Page.
Little Ocmulgee River at:
description [illegible]
discharge [illegible]
Sugar Creek at:
description [illegible]
discharge [illegible]
Wiley, Ga.
Tiger Creek at:
description [illegible]
discharge [illegible]
Williamsons Swamp Creek at—
Davisboro, Ga.:
description 54–55
discharge 55
gage heights [illegible]
Withlacoochee River at—
Dunnellon, Fla.:
description [illegible]
discharge [illegible]
Woodbury, Ga.
Flint River near:
description 105–106, 119
discharge 106, 119
discharge, monthly 120
gage heights 107
rating table 108
Red Oak Creek near:
description 119–120
discharge 120
Yellow River near—
Jackson, Ga.:
description [illegible]
discharge [illegible]
Oak Grove, Fla.:
description [illegible]
discharge [illegible]

O

PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Water-Supply Paper No. 127.]

The publications of the United States Geological Survey consist of (1) Annua. Reports; (2) Monographs; (3) Professional Papers; (4) Bulletins; (5) Mineral Resources; (6) Water-Supply and Irrigation Papers; (7) Topographic Atlas of United States, folios and separate sheets thereof; (8) Geologic Atlas of United States, folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

Most of the above publications may be obtained or consulted in the following ways:

1. A limited number are delivered to the Director of the Survey, from whom they may be obtained, free of charge (except classes 2, 7, and 8), on application.

2. Every member of Congress is allotted a certain number, from whom they may be obtained, free of charge, on application.

3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they may be had at practically cost.

4. Copies of all Government publications are furnished to the principal public libraries in the large cities throughout the United States, where they may be consulted by those interested.

The Professional Papers, Bulletins, and Water-Supply Papers treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous; H, Forestry; I, Irrigation; J, Water storage; K, Pumping water; L, Quality of water; M, General hydrographic investigations; N, Water power; O, Underground waters; P, Hydrographic progress reports.

Series P.—The hydrographic progress reports contain the results of stream measurements. A report is issued for every calendar year, containing the results of data collected during that year. These reports were first published as a part of the Director's annual report or as a bulletin; they are now published as water-supply and irrigation papers. The following is a list, by years, of the publications containing the progress reports of stream measurements. A detailed index of these reports (1888–1903) is published as Water-Supply Paper No. 119.

1888. Tenth Annual Report, Part II.
1889. Eleventh Annual Report, Part II.
1890. Twelfth Annual Report, Part II.
1891. Thirteenth Annual Report, Part III.
1892. Fourteenth Annual Report, Part II.
1893. Bulletin No. 131.
1894. Bulletin No. 131; Sixteenth Annual Report, Part II.
1895. Bulletin No. 140.
1896. Water-Supply Paper No. 11; Eighteenth Annual Report, Part IV.
1897. Water-Supply Papers Nos. 15 and 16; Nineteenth Annual Report, Part IV.
1898. Water-Supply Papers Nos. 27 and 28; Twentieth Annual Report, Part IV.
1899. Water-Supply Papers Nos. 35, 36, 37, 38, and 39; Twenty-first Annual Report, Part IV.
1900. Water-Supply Papers Nos. 47, 48, 49, 50, 51, and 52; Twenty-second Annual Report, Part IV.
1901. East of Mississippi River, Water-Supply Papers Nos. 65 and 75.
West of Mississippi River, Water-Supply Papers Nos. 66 and 75.
1902. East of Mississippi River, Water-Supply Papers Nos. 82 and 83.
West of Mississippi River, Water-Supply Papers Nos. 84 and 85.

1903. East of Mississippi River, Water-Supply Papers Nos. 97 and 98.
West of Mississippi River, Water-Supply Papers Nos. 99 and 100.
1904. East of Mississippi River, Water-Supply Papers Nos. 124, 125, 126, 127, 128, and 129.
West of Mississippi River, Water-Supply Papers Nos. 130, 131, 132, 133, 134, and 135.

The Geological Survey and the Reclamation Service have suboffices in different parts of the United States, from which hydrographic and reclamation work in the respective localities is carried on and where data may be obtained on application. These offices are located as follows:

Boston, Mass., 6 Beacon street; Utica, N. Y., 75 Arcade; Atlanta, Ga., 409 Temple court; Austin, Tex., University of Texas; Chicago, Ill., Federal Building; Belle Fourche, S. Dak.; Cody, Wyo., Denver, Colo., Chamber of Commerce Building; Salt Lake, Utah; Los Angeles, Cal., 1108 Braly Building; San Francisco, Cal., 422 Merchants' Exchange Building; Phoenix, Ariz.; Carlsbad, N. Mex.; El Paso, Tex.; Billings, Mont.; Great Falls, Mont.; Hazen, Nev.; Boise, Idaho; Spokane, Wash., 424 Peyton Block; Pendleton, Oreg.

Correspondence should be addressed to

THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, D. C.

JUNE, 1905.

LIBRARY CATALOGUE SLIPS.

[Mount each slip upon a separate card, placing the subject at the top of the second slip. The name of the series should not be repeated on the series card, but the additional numbers should be added, as received, to the first entry.]

Author.

U. S. Geological survey.

. . . Report of progress of stream measurements for the calendar year 1904. Prepared under the direction of F. H. Newell by M. R. Hall and John C. Hoyt. Pt. IV.—Santee, Savannah, Ogeechee, and Altamaha rivers and eastern Gulf of Mexico drainage. Washington, Gov't print. off., 1905.

192, iii p. illus. II pl. (incl. map) 23cm. (Water-supply and irrigation paper no. 127)

Subject series: P, Hydrographic progress reports, 32.

1. Stream measurements. 2. Rivers—U. S. I. Hall, Maxcy R. II. Hoyt, John Clayton, 1874–

Subject.

U. S. Geological survey.

. . . Report of progress of stream measurements for the calendar year 1904. Prepared under the direction of F. H. Newell by M. R. Hall and John C. Hoyt. Pt. IV.—Santee, Savannah, Ogeechee, and Altamaha rivers and eastern Gulf of Mexico drainage. Washington, Gov't print. off., 1905.

192, iii p. illus. II pl. (incl. map) 23cm. (Water-supply and irrigation paper no. 127)

Subject series: P, Hydrographic progress reports, 32.

1. Stream measurements. 2. Rivers—U. S. I. Hall, Maxcy R. II. Hoyt, John Clayton, 1874–

Series.

U. S. Geological survey.

Water-supply and irrigation papers.

no. 127. Report of progress of stream measurements for . . . 1904 . . . by M. R. Hall and J. C. Hoyt. Pt. IV. 1905.

Reference.

U. S. Dept. of the Interior.

see also

U. S. Geological survey.

Water-Supply and Irrigation Paper No. 128 Series P, Hydrographic Progress Reports, 33

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

REPORT

OF

PROGRESS OF STREAM MEASUREMENTS

FOR

THE CALENDAR YEAR 1904

PREPARED UNDER THE DIRECTION OF F. H. NEWELL
BY
M. R. HALL, E. JOHNSON, Jr., and JOHN C. HOYT

PART V.—Eastern Mississippi River Drainage

WASHINGTON
GOVERNMENT PRINTING OFFICE
1905

CONTENTS.

	Page.
Letter of transmittal	5
Introduction	7
Cooperation and acknowledgments	17
Mississippi River drainage basin	18
Mississippi River near Sauk Rapids, Minn	18
Chippewa River drainage basin	20
Chippewa River near Eau Claire, Wis	20
Flambeau River near Ladysmith, Wis	22
Wisconsin River drainage basin	25
Wisconsin River at Merrill, Wis	25
Wisconsin River near Necedah, Wis	28
Rock River drainage basin	31
Rock River at Rockton, Ill	31
Illinois River drainage basin	34
Illinois River near Minooka, Ill	35
Illinois River at Ottawa, Ill	37
Illinois River near Peoria, Ill	39
Des Plaines River above Jackson Creek, near Channahon, Ill	40
Miscellaneous measurements	44
Allegheny River drainage basin	44
Allegheny River at Redhouse, N. Y	45
Allegheny River at Kittanning, Pa	47
Chadakoin River at Jamestown, N. Y	48
Kiskiminitas River at Salina, Pa	49
Blacklick Creek at Blacklick, Pa	50
Monongahela River drainage basin	51
Cheat River near Morgantown, W. Va	52
Youghiogheny River at Friendsville, Md	54
Youghiogheny River near Confluence, Pa	56
Casselman River at Confluence, Pa	57
Laurel Hill Creek at Confluence, Pa	58
Mahoning River drainage basin	59
Mahoning River at Youngstown, Ohio	60
Muskingum River drainage basin	62
Licking River at Pleasant Valley, Ohio	63
Kanawha River drainage basin	65
New River at Radford, Va	66
New River at Fayette, W. Va	68
Greenbrier River at Alderson, W. Va	70
Scioto River drainage basin	74
Scioto River near Columbus, Ohio	74
Olentangy River near Columbus, Ohio	77
Little Miami River drainage basin	80
Mad River near Springfield, Ohio	80
Wabash River drainage basin	82
Wabash River at Logansport, Ind	83

	Page.
Wabash River drainage basin—Continued.	
Tippecanoe River near Delphi, Ind	86
White River (West Branch) at Indianapolis, Ind	89
Eel River (lower) near Cataract, Ind	91
White River (East Branch) at Shoals, Ind	93
Cumberland River drainage basin	96
Cumberland River at Nashville, Tenn	96
Tennessee River drainage basin	98
French Broad River at Horseshoe, N. C	98
French Broad River at Bingham Bridge near Asheville, N. C	99
French Broad River at Smith Bridge, near Asheville, N. C	100
French Broad River at Oldtown near Newport, Tenn	101
Swannanoa River at Biltmore, N. C	104
Tennessee River near Knoxville, Tenn	104
Tennessee River at Chattanooga, Tenn	107
Davidsons River near Davidsons River, N. C	109
Avery Creek at Davidsons River, N. C	110
Little River at Calhoun, N. C	111
Mills River (North Fork) at Pinkbed, N. C	112
Mills River (South Fork) near Sitton, N. C	114
Pigeon River at Newport, Tenn	116
Nolichucky River near Greeneville, Tenn	119
Holston River (South Fork) at Bluff City, Tenn	122
Holston River at Austins Mills near Rogersville, Tenn	124
Wautauga River near Elizabethton, Tenn	126
Doe River at Elizabethton, Tenn	129
Little Tennessee River at Judson, N. C	130
Tuckasegee River at Bryson, N. C	133
Hiwassee River at Murphy, N. C	135
Hiwassee River at Reliance, Tenn	138
Valley River at Tomotla, N. C	141
Nottely River near Ranger, N. C	143
Ocoee River at McCays, Tenn	146
Fightingtown Creek at McCays, Tenn	148
Paint Rock River near Paintrock, Ala	149
Flint River at Brownsboro, Ala	150
Elk River near Elkmont, Ala	150
Big Spring at Tuscumbia, Ala	152
Duck River at Columbia, Tenn	153
Miscellaneous measurements	154
Yazoo River drainage basin	157
Yazoo River at Yazoo City, Miss	158
Index	161

ILLUSTRATIONS.

	Page.
PLATE I. Map showing location of principal gaging stations in the United States	8
II. Price electric current meters, with buzzers	10
FIG. 1. Cable station, showing section of the river, car, gage, etc	9

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
HYDROGRAPHIC BRANCH,
Washington, D. C., March 2, 1905.

SIR: I transmit herewith the manuscript of Part V of a series of twelve papers which compose the Report of Progress of Stream Measurements for the Calendar Year 1904. Parts I to VI of this report contain the results of the data collected in the territory east of the Mississippi River. Parts VII to XII are devoted to the data collected in the territory west of the Mississippi River.

The larger part of the original data for this report was collected under the direction of district hydrographers M. R. Hall and E. Johnson, jr. Mr. Hall covered the territory south of and including Tennessee River and was assisted by Warren E. Hall, J. M. Giles, and B. S. Drane. Mr. Johnson had the northern portion of the drainage and was assisted by F. W. Hanna and R. W. Pratt. The assembling of the data and its preparation for publication were done under the direction of John C. Hoyt, who has been assisted by R. H. Bolster, Robert Follansbee, Willis E. Hall, A. H. Horton, H. D. Comstock, F. H. Tillinghast, and H. M. Morse.

I request that this manuscript be published as one of the series of Water-Supply and Irrigation Papers.

Very respectfully,

F. H. NEWELL, *Chief Engineer.*

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

PROGRESS REPORT OF STREAM MEASUREMENTS FOR THE CALENDAR YEAR 1904.

PART V.

By M. R. HALL, E. JOHNSON, Jr., and JOHN C. HOYT.

INTRODUCTION.

The hydrographic work of the United States Geological Survey includes the collection of facts concerning and the study of conditions affecting the behavior of water from the time it reaches the earth as rain or snow until it joins the oceans or great navigable rivers. These investigations became a distinct feature of the work of the Survey in the fall of 1888, when an instruction camp was established at Embudo, N. Mex. Since that date the work has been continually and gradually extended as larger funds became available. The first distinctive appropriation for gaging streams was made by the act of August 18, 1894, which contained an item of $12,500, "for gaging the streams and determining the water supply of the United States, including the investigation of underground currents and artesian wells in the arid and semiarid sections." (Digest of Appropriations for 1895, p. 270.)

Since that time a similar act has been passed each year and the appropriations have gradually increased, as shown in the following table:

Annual appropriations for hydrographic surveys.

Year ending June 30, 1895	$12,500
Year ending June 30, 1896	25,000
Year ending June 30, 1897	50,000
Year ending June 30, 1898	50,000
Year ending June 30, 1899	50,000
Year ending June 30, 1900	50,000
Year ending June 30, 1901	100,000
Year ending June 30, 1902	100,000
Year ending June 30, 1903	200,000
Year ending June 30, 1904	200,000
Year ending June 30, 1905	200,000
Year ending June 30, 1906	200,000

The chief feature of the work of the hydrographic division is the systematic study of the flow of the surface waters and the conditions affecting the same. In this connection other information that may be of use to the engineer or others in hydrographic studies, such as river profiles, duration and extent of damage by floods, water-power data, etc., is collected. Furthermore, the work has been so directed that the information collected will be of direct value in the commercial and agricultural development of the country.

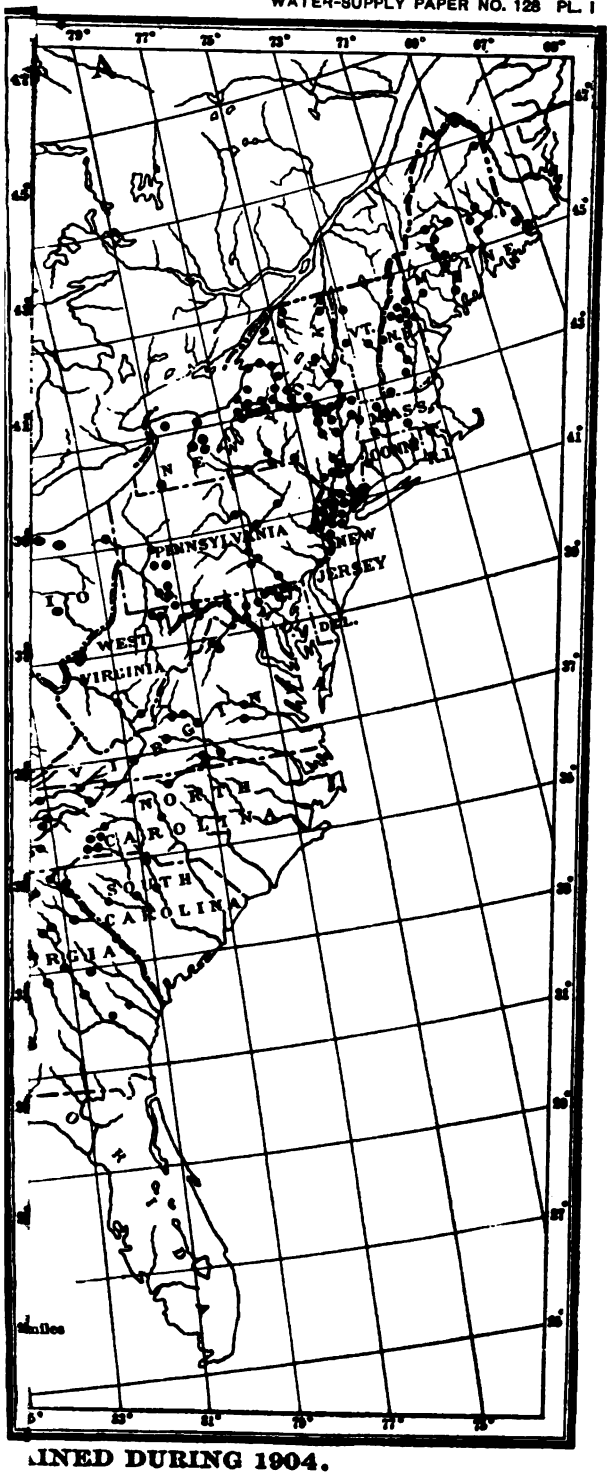
As a result of the increased appropriations since June 30, 1902, the work has been largely extended and thoroughly systemized. The various States have been grouped into districts, each of which is under the supervision of a district hydrographer who, with a corps of assistants, devotes his whole time to the study of the hydrographic resources of his district.

The methods used in the collection of these data and in their preparation for publication are given in detail in Water-Supply Paper No. 94. (Hydrographic Manual, U. S. Geol. Survey.)

The general plan of stream gaging which has been developed is to obtain eventually data in regard to the flow of all the important streams in the United States. With this in view gaging stations are established at points where the data will be of greatest commercial value. At these stations discharge measurements are taken from time to time at typical river stages, and the daily surface fluctuation is obtained by means of gage readings. From these two factors it is possible to estimate both the total flow and its distribution through the period of observation.

The selection of the site for a gaging station and the length of time the station is maintained depend largely upon the needs of each locality. If the stream is to be used for water power, special efforts are made to obtain information concerning the low-water flow. If water is to be stored, the high waters are given special attention. In all sections certain permanent stations are maintained for general statistical purposes to show the conditions which exist through long periods. They also act as primary stations, and are used in connection with short series of measurements to determine the flow in particular portions of the drainage basin.

Gaging stations are divided into two general classes: First, current-meter stations, and, second, weir stations. The former class is subdivided as to location into bridge, cable, boat, and wading stations. Fig. 1 shows a cable station with car, tag line, inclined gage, etc. In addition to the bridge, cable, or boat, the equipment of a current-meter gaging station consists in a gage for determining the daily fluctuations of the water surface, bench marks to which the zero of the gage is referred, and permanent marks on the bridge or a tagged line indicating the points of measurement. Where the current is



INED DURING 1904.

ry to

l con-
nipu-
The
nel is
there
ream
erma-
ow at
nents
s are
nt of
egree

ed by
n the
ested

s the
leter-
Price
l. II,
small
using

ty of
ity is
func-
ough-
f the

The chief feature of the work of the hydrographic division is the systematic study of the flow of the surface waters and the conditions affecting the same. In this connection other information that may be of use to the engineer or others in hydrographic studies, such as river profiles, duration and extent of damage by floods, water-power data, etc., is collected. Furthermore, the work has been so directed that the information collected will be of direct value in the commercial and agricultural development of the country.

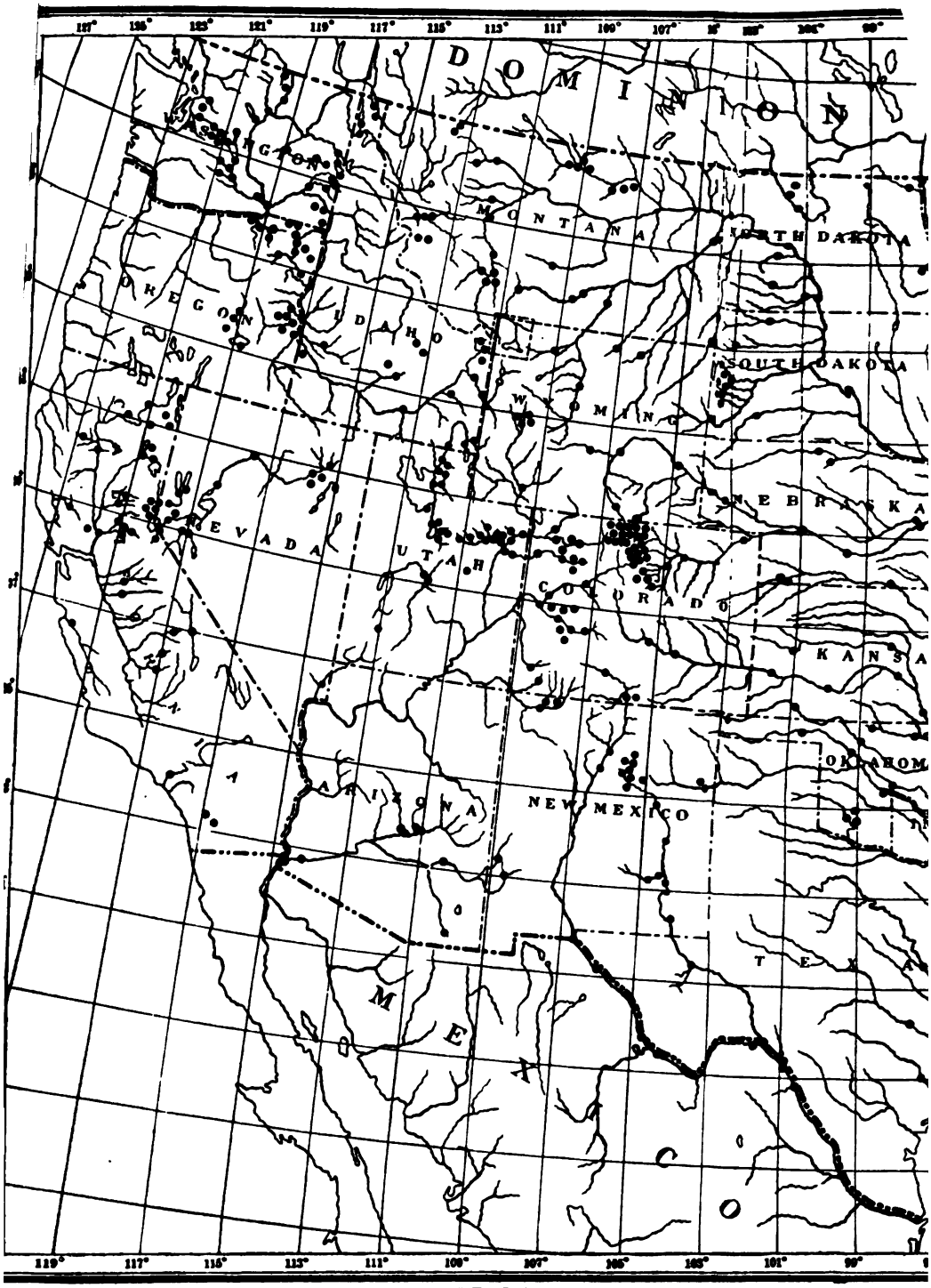
As a result of the increased appropriations since June 30, 1902, the work has been largely extended and thoroughly systemized. The various States have been grouped into districts, each of which is under the supervision of a district hydrographer who, with a corps of assistants, devotes his whole time to the study of the hydrographic resources of his district.

The methods used in the collection of these data and in their preparation for publication are given in detail in Water-Supply Paper No. 94. (Hydrographic Manual, U. S. Geol. Survey.)

The general plan of stream gaging which has been developed is to obtain eventually data in regard to the flow of all the important streams in the United States. With this in view gaging stations are established at points where the data will be of greatest commercial value. At these stations discharge measurements are taken from time to time at typical river stages, and the daily surface fluctuation is obtained by means of gage readings. From these two factors it is possible to estimate both the total flow and its distribution through the period of observation.

The selection of the site for a gaging station and the length of time the station is maintained depend largely upon the needs of each locality. If the stream is to be used for water power, special efforts are made to obtain information concerning the low-water flow. If water is to be stored, the high waters are given special attention. In all sections certain permanent stations are maintained for general statistical purposes to show the conditions which exist through long periods. They also act as primary stations, and are used in connection with short series of measurements to determine the flow in particular portions of the drainage basin.

Gaging stations are divided into two general classes: First, current-meter stations, and, second, weir stations. The former class is subdivided as to location into bridge, cable, boat, and wading stations. Fig. 1 shows a cable station with car, tag line, inclined gage, etc. In addition to the bridge, cable, or boat, the equipment of a current-meter gaging station consists in a gage for determining the daily fluctuations of the water surface, bench marks to which the zero of the gage is referred, and permanent marks on the bridge or a tagged line indicating the points of measurement. Where the current is



MAP OF THE UNITED STATES, SHOWING LOCATION OF

The
syster
affecti
of use
profil
etc., i
the in
agricu
As
work
vario
the s
ants,
of his
Th
ratio
94.
Th
obtai
in th
lishe
At th
at ty
mean
estim
obser
Th
the s
ity.
made
is to
sectic
tical
They
short
porti
Ga
mete
divid
Fig.
addit
mete
fluct
the g
line

swift some appliance, generally a secondary cable, is necessary to hold the meter below the surface.

Gaging stations are generally located at bridges, if the channel conditions are satisfactory, as from them the meter can be easily manipulated, and the cost of the equipment is comparatively small. The stations are located as far as possible at points where the channel is straight, both above and below the gaging section, and where there are no cross currents, backwater, or boils. The bed of the stream should be as clear as possible from large projections and of a permanent character. The banks should be high, and should overflow at high stages only. At stations with shifting beds more measurements are made, and special methods of computing daily discharges are employed. Great care is taken in the selection and equipment of gaging stations in order that the data may have the required degree of accuracy.

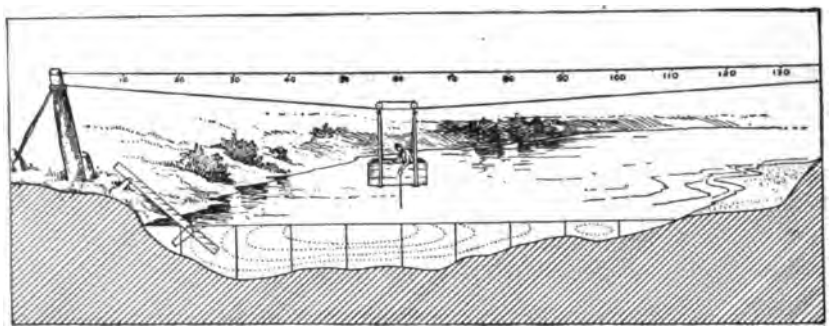


FIG. 1.—Cable station, showing section of river, car, gage, etc.

On many of the larger rivers, where water power is developed by dams, estimates of flow are obtained by observing the head on the crest and using a weir formula. On the smaller streams sharp-crested weirs are in some cases erected.

The principal instrument used in stream-measurement work is the current meter, by which the velocity of the flow of water is determined. After years of experience the Survey has adopted the Price current meter for general work. This meter, as is shown on Pl. II, is made in two sizes, known as the large and small Price. The small Price has been largely developed by the officers of the Survey, using the Price acoustic meter as a basis.

A discharge measurement is the determination of the quantity of water flowing past a certain point at a given time. This quantity is the product of two factors: (1) The mean velocity, which is the function of the cross section, surface slope, wetted perimeter, and roughness of bed; (2) the area, which depends upon the permanency of the bed and the fluctuations of the surface, which govern the depth.

In making the measurement an arbitrary number of points are laid off perpendicular to the thread of the stream (see fig. 1). These points are usually at regular intervals varying from 2 to 20 feet, depending upon the size and conditions of the stream. They are known as measuring points, and at them the observed data, the velocities and soundings, are taken. The perpendiculars dropped from the measuring points divide the gaging section into strips, and for each strip or pair of strips the mean velocity, area, and discharge are determined independently; thus conditions existing in one part of the stream are not distributed to parts where they do not apply.

The methods of obtaining velocity with the current meters which are in general use may be grouped into three classes: Single point, multiple point, and integration.

The single-point method consists in holding the meter either at the depth of the thread of mean velocity, or at an arbitrary depth for which the coefficient for reducing to mean velocity has been determined. Extensive experiments by vertical velocity-curves show that the thread of mean velocity lies at from 0.5 to 0.7 of the total depth. In general practice the thread of mean velocity is considered to be at 0.6 depth, and it is at this depth that the meter is held in the majority of the measurements, this being known as the six-tenth depth method. It is found by a large number of vertical velocity-curve measurements, taken on various streams and under various conditions, that the coefficient for reducing the velocity obtained at six-tenths depth to mean velocity is practically unity, ranging, in a series of 910 measurements made at 39 gaging stations, between .94 and 1.04, with a mean for the 910 observations of 1.00. In the other principal single-point method the meter is held near the surface, usually 1 foot below, or low enough to be out of the action of the wind or other disturbing influences. This is known as the subsurface method. The coefficient for reducing the velocities taken at the subsurface has been found by repeated experiments with vertical velocity-curves to be from .85 to .95, depending upon the depth of the stream and velocity and channel conditions. This method is specially adapted for flood measurements, or when the velocity is so great that the meter can not be kept at 0.6 depth.

The three principal multiple-point methods in general use are: The vertical velocity curve; top and bottom; and top, bottom, and mid depth. In the vertical velocity-curve method a series of velocity determinations are taken in the vertical at regular intervals, usually from 0.5 to 1 foot apart. By plotting these velocities as abscissas and their depths as ordinates, and drawing a smooth curve through these points, the vertical velocity-curve is produced, which shows the change in velocity from the surface to the bottom of the stream. The mean velocity in the vertical is then obtained by dividing the depth

PRICE ELECTRIC CURRENT METERS, WITH BUZZERS.

into the area bounded by this mean velocity curve and the initial line. Owing to the length of time it takes to make these measurements they are seldom used except for determining coefficients for purposes of comparison and for measurements under ice.

In the second multiple-point method the meter is held from 0.5 to 1 foot below the surface and about 0.5 foot above the bottom, and the mean of the velocities at these two points is taken as the mean velocity for that vertical. This method is not well adapted for general work, as the roughness of the bottom disturbs the velocity at that point. For shallow streams with comparatively smooth beds good results are obtained by this method. In the third multiple point method the meter is held at mid depth, 0.5 foot below the surface, and 0.5 foot above the bottom, and the mean velocity is determined by dividing the sum of the top velocity, twice the mid-depth velocity, and the bottom velocity by 4.

The vertical-integration method consists in moving the meter at a slow, uniform speed from the surface to the bottom and back again to the surface. The number of revolutions and the time taken in the operation is noted, and the mean velocity is found by dividing the number of revolutions by the number of seconds taken in the run. This method has the advantage in that the velocity at each point of the vertical is measured twice. It is well adapted for measurements under ice and as a check on the point methods.

The area, which is the other factor for determining the discharge of the stream, depends upon the stage of the river, which is taken on a gage, and the general contour of the bed of the stream, which is found by sounding. The soundings are usually taken at each measuring point at the time of the discharge measurement, either by using the meter and cable or by a special sounding line or rod. For stations with permanent beds standard cross sections are usually taken during low water. These sections serve to check the soundings which are taken at the time of the measurements, and from them any change which may have taken place in the bed of the stream can be detected. They are also used for obtaining the area for use in high-water measurement computations, as accurate soundings are hard to obtain at high stages.

In computing the discharge measurements from the observed velocities and depths at the various points of measurements the measuring section is divided into elementary strips, as shown in fig. 1, and the mean velocity, area, and discharge are determined separately for either a single or double strip. The total discharge and area are the sums of those for the various strips, and the mean velocity is obtained by dividing the total discharge by the total area.

The volume of water flowing in a stream is known as run-off. In expressing it various units are used, depending upon the kind of work for which the data are needed. Those used in this report are "second-

feet," "acre-feet," "run-off per square mile," and "run-off in depth in inches," and may be defined as follows:

"Second-foot" is an abbreviation for cubic foot per second, and is the body of water flowing in a stream 1 foot wide, 1 foot deep, at a rate of 1 foot per second.

The "acre-foot" is the unit of capacity used in connection with storage for irrigation work, and is equivalent to 43,560 cubic feet. It is the quantity required to cover an acre to a depth of 1 foot. There is a convenient relation between the second-foot and the acre-foot: 1 second-foot flowing for twenty-four hours will deliver 86,400 cubic feet, which equals 1.9835 acre-feet, or, approximately, 2 acre-feet.

The expression "second-feet per square mile" means the average number of cubic feet of water flowing each second from every square mile of drainage area on the assumption that the run-off is uniformly distributed.

"Depth in inches" means the depth of water in inches that would have covered the drainage area, uniformly distributed, if all the water could have accumulated on the surface. This quantity is used for comparing run-off with rainfall, which quantity is usually given in depth in inches.

It should be noticed that "acre-feet" and "depth in inches" represent the actual quantities of water which are produced during the periods in question, while "second-feet," on the contrary, is merely a rate of flow per second.

The base data for computing the daily discharge of a stream are the daily gage heights, and the various discharge measurements of which there should be sufficient number to cover the range of stage. The fundamental laws upon which these computations are based are the following:

(1) The discharge will remain constant so long as the conditions at or near the gaging station remain constant;

(2) Neglecting the change of slope due to the rise and fall of the stream, the discharge will be the same whenever the stream is at a given stage; and

(3) The discharge is both a function of, and increases gradually with, the gage heights. (2 and 3 depend on 1).

As the beds of many streams are changeable, the problem divides itself into two classes: (1) Those of streams with permanent, or practically permanent, beds, and (2) those of streams with changeable beds. The base data and methods of obtaining them are the same for either class, and it is only in the computation of the mean daily flow that different methods are necessary.

In determining the daily discharge of streams with permanent beds the results of the discharge measurements are plotted on cross-section paper, with gage heights as ordinates and discharges as abscissas. Through these points a smooth curve is drawn, which shows the dis-

charge for any gage height, and from which a rating table is prepared. Aside from plotting the discharge, the mean velocity and area determined for each discharge measurement are plotted. Through these points the curves of mean velocity and of area are drawn, and the rating curve is largely determined by taking the product of the mean velocity and the area at various stages as determined by these curves. These curves of mean velocity and area are of special value to determine the location of the rating curve for stages at which actual discharge measurements are not available and for extending the discharge curve outside the limits of the measurements. In the preparation of the rating table the discharge for each tenth or half tenth on the gage is found from the curve. The first and second differences of these discharges are then taken and adjusted according to the law that they shall either be constant or increasing, never decreasing. The discharges in the table are then changed in accordance with these adjusted differences. In making up the station-rating curve the individual discharge measurements and the conditions under which they were taken are carefully studied, in order that proper weight shall be given to each measurement. Rating curves in general take the form of a parabola, and as a rule the high-water portion of the curve approaches a straight line. For stations of permanent character the results of the measurements from year to year should be within 5 per cent of the curve, with the exception of those taken during high water, when the probable error may be as high as 10 per cent.

The determination of the daily discharge of streams with changeable beds is difficult, and unless frequent discharge measurements are made the results obtained are only roughly approximate. For streams with continually shifting beds, such as Colorado River and the Rio Grande, discharge measurements are made every two or three days, and the discharges for the intervening days are obtained by interpolation, modified by the gage heights for these days. For stations with beds which shift slowly, or are only materially changed during floods, station-rating curves and tables can be prepared for the periods between changes, and satisfactory results can be obtained with two or three measurements a month, providing measurements are taken soon after the changes take place.

In determining the flow for periods when the streams are frozen, special rating curves and tables have to be prepared from measurements taken under these conditions. The methods of constructing these curves and tables are the same as for open sections. The discharge measurements, however, are either taken by integration in verticals or by the vertical velocity-curve method, as sufficient experiments have not been made on ice-covered streams to determine the laws which govern the position of the thread of mean velocity.

The Report of Progress of Stream Measurements for the Calendar Year 1904, of which this is Part V, is published in a series of twelve Water-Supply Papers, Nos. 124–135, inclusive, under the following subtitles:

Part 1. Atlantic coast of New England drainage.
Part 2. Hudson, Passaic, Raritan, and Delaware River drainages.
Part 3. Susquehanna, Patapsco, Potomac, James, Roanoke, Cape Fear, and Yadkin River drainages.
Part 4. Santee, Savannah, Ogeechee, Altamaha rivers, and Eastern Gulf of Mexico drainage.
Part 5. Eastern Mississippi River drainage.
Part 6. Great Lakes and St. Lawrence River drainage.
Part 7. Hudson Bay, Minnesota, Wapsipinicon, Iowa, Des Moines, and Missouri River drainages.
Part 8. Platte, Kansas, Meremac, Arkansas, and Red River drainages.
Part 9. Western Gulf of Mexico drainage.
Part 10. Colorado River and Great Basin drainage.
Part 11. The Great Basin and Pacific Ocean drainage in California.
Part 12. Columbia River and Puget Sound drainage.

The territory covered by each paper is given in the subtitle, and the larger drainages are, for convenience in arrangement, subdivided into smaller ones, under which the data are arranged, as far as practicable, geographically.

These papers contain the data that have been collected at the regular gaging stations, the results of the computations based upon the observations and such other information that has been collected that has a direct bearing on these data including, as far as practicable, descriptions of the drainage areas and the streams draining them.

For each regular station are given, as far as available, the following data:

1. Description of station.
2. List of discharge measurements.
3. Gage-height table.
4. Rating table.
5. Table of estimated monthly and yearly discharges and run-off.

The descriptions of stations give, as far as possible, such general facts about the locality and equipment as would enable the reader to find the station and use the same. They also give, as far as possible, a complete history of all the changes that have occurred since the establishment of the station that would be factors in using the data collected.

The discharge-measurement table gives the results of the discharge measurements made during the year. This includes the date, the hydrographer's name, the gage height, and the discharge in second-feet.

The table of daily gage heights gives for each day the mean height of the surface of the river as found from the mean of the gage read-

ings taken on that day. At most of the stations the gage is read in the morning and in the evening.

The rating table gives discharges in second-feet corresponding to each stage of the river as given by the gage heights.

In the table of estimated run-off the column headed "Maximum" gives the mean flow for the day when the mean gage height was the highest, and it is the flow as given in the rating table for that mean gage height. As the gage height is the mean for the day, there might have been short periods when the water was higher and the corresponding discharge larger than given in this column. Likewise in the column of "Minimum" the quantity given is the mean flow for the day when the mean gage height was lowest. The column headed "Mean" gives the average flow for each second during the month. Upon this mean the computations for the three remaining columns which are defined on page 12 are based.

In the computations for the tables of this report the following general and special rules have been used:

Fundamental rules for computation.

1. The highest degree of precision consistent with the rational use of time and money is imperative.

2. All items of computation should in general be expressed by at least two and by not more than four significant figures.

3. Any measurement in a vertical velocity, mean velocity, or discharge curve whose per cent of error is 5 times the average per cent error of all the other measurements should be rejected.

4. In reducing the number of significant figures, or the number of decimal places, by dropping the last figure, the following rules apply:

(a) When the figure in the place to be rejected is less than 5, drop it without changing the preceding figure. Example: 1,827.4 becomes 1,827.

(b) When the figure in the place to be rejected is greater than 5, drop it and increase the preceding figure by 1. Example: 1,827.6 becomes 1,828.

(c) When the figure in the place to be rejected is 5, and it is preceded by an even figure, drop the 5. Example: 1,828.5 becomes 1,828.

(d) When the figure in the place to be rejected is 5, and it is preceded by an odd figure, drop the 5 and increase the preceding figure by 1. Example: 1,827.5 becomes 1,828.

5. In constructing and applying rating tables a maximum limit of one-half per cent error should seldom be exceeded.

Special rules for computation.

1. Rating tables are to be constructed as close as the data upon which they are based will warrant. No decimals are to be used when the discharge is over 50 second-feet.

2. Daily discharges shall be applied directly to the gage heights as they are tabulated.

3. Monthly means are to be carried out to one decimal place when the quantities are below 100 second-feet. Between 100 and 10,000 second-feet, the last figure in the monthly mean shall be a significant figure. This also applies to the yearly mean.

4. Second-feet per square mile and depth in inches for the individual months shall be carried out at least to three significant figures, except in the case of decimals where the first significant figure is preceded by one or more naughts (0), when the quantity shall be carried out to two significant figures. Example: 1.25; .125; .012; .0012. The yearly means for these quantities are always to be expressed in three significant figures and at least two decimal places.

The results of the stream measurements made during previous years by the United States Geological Survey can be found in the following Survey publications. A detailed index of these reports is given in Water-Supply Paper No. 119.

1888. Tenth Annual Report, Part II.
1889. Eleventh Annual Report, Part II.
1890. Twelfth Annual Report, Part II.
1891. Thirteenth Annual Report, Part III.
1892. Fourteenth Annual Report, Part II.
1893. Bulletin No. 131.
1894. Bulletin No. 131; Sixteenth Annual Report, Part II.
1895. Bulletin No. 140.
1896. Water-Supply Paper No. 11; Eighteenth Annual Report, Part IV.
1897. Water-Supply Papers Nos. 15 and 16; Nineteenth Annual Report Part IV.
1898. Water-Supply Papers Nos. 27 and 28; Twentieth Annual Report Part IV.
1899. Water-Supply Papers Nos. 35 to 39, inclusive; Twenty-first Annual Report, Part IV.
1900. Water-Supply Papers Nos. 47 to 52, inclusive; Twenty-second Annual Report, Part IV.
1901. East of Mississippi River, Water-Supply Papers Nos. 65 and 75.
West of Mississippi River, Water-Supply Papers Nos. 66 and 75.
1902. East of Mississippi River, Water-Supply Papers Nos. 82 and 83.
West of Mississippi River, Water-Supply Papers Nos. 84 and 85.
1903. East of Mississippi River, Water-Supply Papers Nos. 97 and 98.
West of Mississippi River, Water-Supply Papers Nos. 99 and 100.
1904. East of Mississippi River, Water-Supply Papers Nos. 124 to 129, inclusive.
West of Mississippi River, Water Supply Papers Nos. 130 to 135, inclusive.

A limited number of these are for free distribution, and as long as the supply lasts they may be obtained by application to the Director United States Geological Survey or to members of Congress. Other copies are filed with the Superintendent of Public Documents, Washington, D. C., from whom they may be had at little above cost. Copies of Government publications are, as a rule, furnished to the public libraries in our large cities, where they may be consulted by those interested.

COOPERATION AND ACKNOWLEDGMENTS.

Most of the measurements presented in this paper have been obtained through local hydrographers. Acknowledgment is extended to other persons and corporations who have assisted local hydrographers or have cooperated in any way, either by furnishing records of the height of water or by assisting in transportation.

The following list, arranged alphabetically by States, gives the names of the resident hydrographers and others who have assisted in furnishing and preparing the data contained in this report:

Alabama.—District hydrographer, M. R. Hall,[a] assisted by J. M. Giles, W. E. Hall, and B. S. Drane.

Illinois.—District hydrographer, E. Johnson, jr.,[b] assisted by E. H. Heilbron, assistant engineer, sanitary district of Chicago. Acknowledgment is due to the Sterling Manufacturing Company for the establishment of two chain gages on the Avenue G bridge, Sterling, Ill.

Indiana.—District hydrographer, E. Johnson, jr., assisted by F. W. Hanna, assistant engineer. Acknowledgment should also be made to Joseph M. Steiner and O. H. Griest, who have assisted the Survey in establishing stations and supplying voluntary readings at Cataract and Shoals, Ind.

Maryland.—Resident hydrographer, E. G. Paul, during the first half and N. C. Grover[c] during the last half of the year, assisted by H. D. Comstock. Acknowledgment is due to the State Geological Survey for cooperation in the work to the extent of paying the observers.

Minnesota.—District hydrographer, E. Johnson, jr., assisted by E. F. Chandler, assistant engineer, University, N. Dak.

Mississippi.—District hydrographer, M. R. Hall, assisted by J. M. Giles, B. S. Drane, and W. E. Hall.

New York.—District hydrographer, R. E. Horton,[d] assisted by C. C. Covert. Special acknowledgment is made of the interest and assistance of Hon. Edward A. Bond, State engineer, and William Pierson Judson, deputy State engineer.

North Carolina.—District hydrographer, M. R. Hall, assisted by J. M. Giles, B. S. Drane, and O. P. Hall. Dr. C. A. Schenck, director of the Biltmore School of Forestry, paid the gage readers at Davidsons River, Sitton, and Pinkbed.

Ohio.—District hydrographer, E. Johnson, jr., assisted by R. W. Pratt, engineer of the State board of health. Acknowledgment should also be made to the Baltimore and Ohio Railroad for passes issued to E. Johnson, jr., and R. W. Pratt.

Pennsylvania.—Resident hydrographer, E. G. Paul during the first half and N. C. Grover during the last half of the year, assisted by R. J. Taylor and H. D. Comstock.

Tennessee.—District hydrographer, M. R. Hall, assisted by J. M. Giles, B. S. Drane, and O. P. Hall. Gage heights for stations at Nashville, Chattanooga, Knoxville, Rogersville, and part of the year at Bluff City, were furnished by United States Weather Bureau officials H. C. Bate, L. M. Pindell, and Levi A. Judkins.

West Virginia.—Resident hydrographer, E. G. Paul in the first half and N. C. Grover in the last half of the year.

Wisconsin.—District hydrographer, E. Johnson, jr.

[a] The office of the district hydrographer for South Atlantic States and Eastern Gulf of Mexico, 409 Temple Court, Atlanta, Ga.

[b] The office of the district hydrographer for Mississippi Valley, 876-7 Federal Building, Chicago, Ill.

[c] The office of the resident hydrographer for North Atlantic States, United States Geological Survey, Washington, D. C.

[d] The office of the district hydrographer for New York and Michigan, 75 Arcade, Utica, N. Y.

MISSISSIPPI RIVER DRAINAGE BASIN.

MISSISSIPPI RIVER NEAR SAUK RAPIDS, MINN.

This station was established by W. R. Hoag April 23, 1903. It is located about 1½ miles south of Watab station, on the Northern Pacific Railroad, and about 5 miles north of Sauk Rapids, 7 miles north of St. Cloud. The gage is a vertical timber fastened to a post driven into the bed on the left side of the river. It is read daily by Frank McCrea. Discharge measurements are made from a boat running on a $\frac{5}{8}$-inch cable, which is securely fastened to trees on each side of the river. The point to which the soundings are referred is a nail head in the root of a tree on the left bank, to which the cable is fastened. The channel is straight for 4,000 feet above the station and for 600 feet below. Both banks are high and not subject to overflow. The bed consists of sand and gravel, and is somewhat shifting. There is but one channel at all stages. The channel has a width of about 625 feet at low water and about 700 feet at high stages.

Bench mark No. 1 is the top of a large pointed rock 150 feet upstream from the gage and 10 feet from the water's edge. Its elevation above the zero of the gage is 18.58 feet. Bench mark No. 2 is a $\frac{3}{8}$-inch iron stake, driven on the left shore between the cable and bench mark No. 1. Its elevation is 14.22 feet above the zero of the gage. Bench mark No. 3 is on the root of a small tree on the left bank just below the cable. Its elevation is 18.29 feet above the zero of the gage. A short distance above the old gage is a large rock with a vertical face at an elevation of 14.45 feet above the zero of the gage. Observations of the river height can be made by determining distance from the top of this rock to the water surface.

The drainage area at this station is 12,340 square miles.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Mississippi River near Sauk Rapids, Minn., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
January 5[a]	E. Johnson, jr.	515	2,201	0.94	10.20	2,473
April 20	E. F. Chandler	585	4,171	2.94	14.26	12,250
July 1	do	577	3,790	2.12	13.31	8,019
July 25	R. Richards	557	2,678	1.77	11.38	4,745
August 22[b]	do	572	3,404	1.28	12.76	4,344
September 8[b]	do	561	2,858	1.68	11.77	4,802
October 15	E. F. Chandler	578	3,815	2.45	13.75	9,348

[a] Frozen over. [b] Log jam below station.

Mean daily gage height, in feet, of Mississippi River near Sauk Rapids, Minn., for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.[a]	Apr.[b]	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.[c]
1	11.60	11.20	11.32	14.00	14.50	13.35	13.30	11.00	12.85	12.20	13.00	11.70
2	11.70	11.20	11.36	14.10	14.30	13.40	13.25	11.05	12.90	12.20	12.90	11.85
3	11.80	11.28	11.44	14.60	14.40	13.60	12.90	11.35	12.90	12.00	12.80	11.85
4	11.80	11.28	11.52	15.50	14.30	14.00	12.75	11.20	11.30	12.00	12.70	11.75
5	[d]11.60	11.28	11.52	15.90	14.25	14.50	12.60	11.05	11.35	12.20	12.60	11.70
6	11.60	11.28	11.53	17.00	14.25	14.65	12.60	11.00	11.40	12.20	12.40	11.75
7	11.60	11.28	11.57	17.00	14.25	14.75	12.85	10.95	11.80	12.10	12.20	11.85
8	11.50	11.28	11.61	19.60	14.30	14.60	12.85	11.00	11.75	12.15	12.20	11.95
9	11.50	11.28	11.61	17.10	14.40	14.45	12.80	11.05	11.70	12.50	12.35	11.60
10	11.48	11.28	11.61	17.00	14.50	14.35	12.65	11.60	11.55	13.60	12.30	11.60
11	11.48	11.32	11.70	15.90	14.60	14.25	12.45	11.70	11.45	13.75	12.30	11.60
12	11.61	11.32	11.70	15.00	14.60	14.10	12.30	11.75	11.40	13.85	12.25	11.40
13	11.61	11.32	11.70	14.70	14.50	13.95	12.50	11.75	11.30	13.90	12.20	11.35
14	11.52	11.32	11.70	14.50	14.45	13.80	12.45	11.65	11.40	13.90	12.15	11.25
15	11.61	11.28	11.70	14.40	14.45	13.65	12.50	11.50	11.50	13.75	11.90	11.15
16	11.70	11.28	11.70	14.40	14.30	13.45	12.60	11.40	11.40	13.75	12.15	11.10
17	11.70	11.24	11.70	14.35	14.30	13.20	12.35	11.80	11.30	13.75	12.05	11.05
18	11.61	11.20	11.70	14.35	14.20	13.10	12.50	11.85	11.30	13.75	12.00	11.00
19	11.61	11.20	11.70	14.35	14.00	12.90	12.65	11.75	11.25	13.95	11.90	10.85
20	11.52	11.28	11.70	14.25	13.80	12.60	12.75	12.60	11.20	14.00	11.80	10.90
21	11.52	11.28	11.78	14.15	13.75	12.55	12.70	12.65	11.40	13.95	11.70	10.90
22	11.44	11.28	11.78	14.05	13.70	12.40	12.50	12.80	11.50	13.90	11.70	10.90
23	11.36	11.28	11.78	14.30	13.50	12.30	11.80	12.45	11.60	13.95	11.70	10.90
24	11.36	11.28	11.78	14.55	13.60	12.15	11.40	12.45	11.65	14.05	11.70	10.90
25	11.36	11.28	11.78	14.60	13.65	12.45	11.30	12.60	11.80	13.90	11.65	10.80
26	11.36	11.28	11.78	14.70	13.50	12.75	11.30	12.80	11.75	13.80	11.65	10.90
27	11.28	11.28	11.90	14.90	13.40	12.80	11.50	12.75	11.75	13.60	11.50	11.00
28	11.28	11.28	11.90	14.80	13.35	12.35	11.30	12.50	12.10	13.50	11.35	11.10
29	11.20	11.28	12.00	14.80	13.25	12.85	11.25	12.40	12.20	13.40	11.10	11.15
30	11.20	.....	12.20	14.70	13.15	13.20	11.20	12.45	12.20	13.30	11.00	11.20
31	11.20	.....	12.70	.....	13.25	.....	11.15	12.80	.....	13.20	.....	11.30

[a] River frozen from January 1 to March 31, 1904. Average thickness of ice about 9 inches.
[b] Ice conditions April 1 to about April 8. April 6 and 7 ice gorge.
[c] Frozen December 1 to 31.
[d] On January 5 from surface of water to under side of ice was 1.3 feet.

CHIPPEWA RIVER DRAINAGE BASIN.

Chippewa River rises in the southeastern part of Ashland County, Wis. It flows southwest, emptying into the Mississippi near Wabasha, Minn. Its principal tributary is the Flambeau, which enters from the east in Gates County. During the latter part of 1902 the United States Geological Survey began systematic measurements in this and other drainage basins of Wisconsin.

Gaging stations have been maintained in this basin on the Chippewa at Eau Claire, and on the Flambeau at Ladysmith, Wis.

CHIPPEWA RIVER NEAR EAU CLAIRE, WIS.

This station was established November 13, 1902, by L. R. Stockman. It is located 2 miles below Eau Claire, at a suburb known as Shawtown. Discharge measurements are made from a two-span highway bridge. A standard chain gage is fastened to the downstream side of highway bridge, having a length of 30.69 feet from the end of the weight to the marker. The gage is read twice each day by Joseph E. Kimpton. The channel is straight above and below the station, and the current is swift. The right bank is protected by a high masonry wall. The left bank is low, but the water is confined by an earthen embankment. The bed is composed of gravel, with a few rocks, and is permanent. There are two channels at all stages. The width is 450 feet at low water and 500 feet at flood stages.

Bench mark No. 1 is a nail in the top of a 6-inch white-oak stump which is attached to a tree still standing. It is located about 200 feet east of the road and 200 feet south of the river. Its elevation is 20.09 feet above the zero of the gage. The initial point for soundings is a point marked by two nails in the footway at the right end of the bridge, also marked 0 in white paint.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Chippewa River near Eau Claire, Wis., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Feet per sec.*	*Feet.*	*Second-ft.*
January 11[a]	E. Johnson, jr	310	2,429	0.99	3.80	2,454
May 14	do	385	4,272	3.42	8.40	14,610
May 24	Johnson and Hanna	370	4,074	3.10	7.60	12,630
June 7	E. Johnson, jr	426	5,815	4.52	11.25	26,270
July 13	do	354	3,770	2.10	6.55	7,918
August 28	do	322	2,766	.82	4.20	2,274
September 19	do	329	3,122	1.47	5.25	4,581
October 12	F. W. Hanna	495	7,118	5.43	14.80	38,680
October 13	do	457	6,137	4.76	13.10	29,200
November 29	E. Johnson, jr	324	2,847	.80	4.44	2,281

[a] Frozen.

Mean daily gage height, in feet, of Chippewa River near Eau Claire, Wis., for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.[a]	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.[b]
1	[c] 4.90			6.25	9.00	8.45	8.10	4.42	4.58	6.31	6.79	3.98
2	[c] 5.15			6.72	8.65	7.65	8.52	4.80	5.05	5.24	6.84	3.92
3				6.50	8.63	7.65	8.28	4.38	8.18	8.27	6.80	3.93
4	[c] 5.00			6.52	8.28	8.85	8.02	4.78	7.52	5.65	6.61	3.45
5			[d] 4.80	6.60	8.10	9.00	10.32	4.32	8.30	5.30	5.91	4.42
6		[e] 4.80		7.17	8.08	10.95	10.12	4.12	7.30	5.27	6.41	4.28
7				7.60	10.13	11.30	9.63	3.45	7.52	4.82	6.08	4.26
8				9.10	8.50	10.85	8.98	4.62	7.12	9.12	5.35	4.28
9	[c] 4.80			9.67	8.83	9.85	7.22	5.10	6.72	7.86	5.35	4.37
10				9.72	9.35	8.92	7.10	5.42	7.95	13.35	5.60	4.36
11				9.70	9.25	7.95	7.20	5.35	5.03	15.07	5.36	4.20
12			[e] 4.95	9.32	8.85	7.80	6.72	4.38	5.28	14.93	5.02	4.34
13		[d] 5.00		9.05	8.78	7.80	6.60	4.12	5.42	13.15	6.27	4.39
14				8.82	10.20	7.45	5.88	3.50	5.35	11.38	4.82	4.20
15				8.50	8.00	7.80	5.07	3.80	5.38	10.30	6.26	4.34
16	[c] 5.00			7.55	8.20	8.35	5.55	4.55	5.42	9.17	5.42	4.32
17				7.25	7.55	6.25	5.35	4.82	7.10	8.10	5.30	4.15
18				7.50	7.22	5.50	5.60	4.65	4.80	8.00	5.47	4.19
19		[d] 5.10	4.45	8.38	7.55	5.10	5.50	4.78	4.89	7.08	5.20	4.53
20			4.07	8.20	6.93	6.20	5.10	7.20	4.27	6.85	4.98	4.29
21			4.45	8.13	10.30	6.50	5.47	5.25	4.30	8.35	5.28	4.34
22			4.37	7.45	6.30	5.90	5.05	4.75	4.35	9.25	5.23	4.37
23	[c] 5.00		4.32	8.05	6.83	5.80	4.75	4.68	5.10	9.42	5.74	4.55
24			5.62	8.50	7.33	5.50	3.93	4.60	4.24	9.00	4.77	4.38
25			5.95	9.65	9.20	8.95	4.07	5.00	5.76	8.78	4.94	3.31
26			6.45	10.63	12.00	5.55	4.90	5.40	8.18	7.81	5.10	4.19
27		[d] 5.30	6.10	10.45	13.48	7.75	4.80	8.15	7.61	8.02	4.85	4.55
28			5.72	9.18	13.63	7.60	5.00	3.58	6.93	7.22	4.55	.....
29	[e] 4.70		5.05	9.55	12.02	7.75	4.88	5.55	9.81	7.55	4.54	.....
30			5.10	9.03	10.67	7.50	6.45	4.92	6.65	7.30	4.46	.....
31			5.32	.....	9.20	.....	5.00	4.52	.....	6.85	.....	.....

[a] River frozen over January 1 to March 18, 1904, but open about 200 to 300 feet above and one-fourth mile below bridge.
[b] Frozen December 28 to 31.
[c] Ice 2.0 feet thick at gage; 1.0 foot in middle of channel.
[d] Ice 2.5 feet thick at gage; 2.5 feet in middle of channel.
[e] Ice 2.0 feet thick at gage; 2.0 feet in middle of channel.

Rating table for Chippewa River near Eau Claire, Wis., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.7	1,240	4.8	3,590	5.9	6,610	8.0	13,290
3.8	1,410	4.9	3,850	6.0	6,900	8.5	14,980
3.9	1,590	5.0	4,120	6.2	7,490	9.0	16,680
4.0	1,780	5.1	4,390	6.4	8,100	9.5	18,380
4.1	1,980	5.2	4,660	6.6	8,720	10.0	20,080
4.2	2,180	5.3	4,930	6.8	9,350	10.5	21,780
4.3	2,390	5.4	5,200	7.0	9,990	11.0	23,480
4.4	2,610	5.5	5,480	7.2	10,650	11.5	25,210
4.5	2,840	5.6	5,760	7.4	11,310	12.0	26,960
4.6	3,080	5.7	6,040	7.6	11,970	13.0	30,500
4.7	3,330	5.8	6,320	7.8	12,630	14.0	34,480

The above table is applicable only for open-channel conditions. It is based upon 23 discharge measurements made during 1902 to 1904, inclusive. It is well defined between gage heights 4.20 feet and 14.80 feet.

Estimated monthly discharge of Chippewa River near Eau Claire, Wis., for 1904.

[Drainage area, 6,740 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
March 19–31	8,255	1,920	4,622	0.686	0.332
April	22,220	7,640	14,550	2.16	2.41
May	32,900	7,790	16,960	2.52	2.90
June	24,510	4,390	12,600	1.87	2.09
July	21,170	1,647	8,525	1.26	1.45
August	13,790	650	3,778	.561	.647
September	19,430	2,264	7,801	1.16	1.29
October	40,400	3,642	15,170	2.25	2.59
November	9,478	2,748	5,576	.827	.923
December 1–27	2,960	380	2,230	.331	.342

FLAMBEAU RIVER NEAR LADYSMITH, WIS.

This station was established February 13, 1903, by L. R. Stockman. It is located three-fourths mile south of the Minneapolis, St. Paul and Sault Ste. Marie Railroad station, three-fourths mile south of Lady-

smith and one-half mile below the dam of the Menasha Pulp Company. Discharge measurements are made from a three-span highway bridge. A standard chain gage is fastened to the upstream side of the right span. The length of the chain from the end of the weight to the marker is 25.40 feet. The gage is read twice each day by Leonard McCandless. The initial point for soundings is a point marked by two nails and a straight white line at the right end of the bridge. The channel is straight for about 500 feet above and below the station. The right bank is low, but the overflow passes beneath the bridge. The left bank is high and covered with trees. The gaging section is broad and shallow, with a bed of small bowlders, gravel, and sand, and is not liable to shift. The stream is divided into three channels by the bridge piers. The channels are somewhat obstructed by log jams during the rafting season. The bench mark is a cut on a rivet head on the post to which the pulley of the chain gage is attached. When the gage reads zero this mark is 36.28 feet above the water surface. An arrow cut on the iron guard rail is exactly opposite the 10-foot mark of the scale of the chain gage.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Flambeau River near Ladysmith, Wis., for 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec. feet.*
February 13[a]	L. R. Stockman	325	472	1.64	16.20	773
March 19[b]	do	366	1,871	1.77	18.95	3,312
April 8	do	349	1,330	2.80	17.40	3,727
May 6	do	361	1,927	3.70	18.97	7,113
June 16	do	342	703	1.91	16.00	1,345
July 11	do	342	1,430	2.95	18.10	4,222
August 21	do	342	995	2.69	16.85	2,681
September 10	E. C. Murphy	364	1,579	3.36	18.05	5,303
October 23	L. R. Stockman	348	1,271	3.07	17.21	3,899
1904.						
May 16	E. Johnson, jr	350	1,333	3.15	17.88	4,203
June 3	do	350	1,448	2.99	17.45	4,321
August 29	do	349	733	2.07	16.06	1,517
September 20	do	343	702	2.21	16.01	1,554
October 12	F. W. Hanna	364	1,653	3.37	18.58	5,588

[a] Frozen. [b] Log jam below.

Mean daily gage height, in feet, of Flambeau River near Ladysmith, Wis., for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.[a]	Apr.[b]	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.[c]
1	16.75	16.75	17.00	16.90	18.70	17.50	17.58	15.15	16.25	(d)	17.25	15.65
2	16.95	16.75	17.05	17.20	18.55	17.40	17.77	15.40	16.30	(d)	17.30	15.05
3	16.75	16.10	17.00	16.80	18.60	17.42	17.70	(e)	16.38	(d)	17.20	15.95
4	16.85	16.80	17.05	16.90	18.35	17.43	19.90	(e)	17.78	(d)	16.90	14.50
5	17.00	16.90	17.15	16.85	18.45	18.00	18.82	15.60	17.65	16.05	16.70	15.15
6	16.50	16.70	16.95	16.80	18.60	18.02	18.88	15.72	17.20	16.05	16.80	15.30
7	16.50	16.80	16.90	17.10	18.60	18.25	18.75	15.13	17.28	16.10	16.90	14.87
8	16.65	16.75	17.15	17.25	18.85	18.27	18.75	15.40	17.30	16.10	16.20	15.75
9	16.65	16.75	16.90	17.05	19.20	17.90	18.05	15.75	17.03	17.05	16.17	15.57
10	16.70	16.65	17.50	17.00	19.15	17.22	17.95	15.92	16.00	18.70	16.15	15.55
11	16.60	16.70	17.40	17.10	18.90	17.10	17.70	15.85	16.40	18.65	16.05	15.25
12	16.55	16.95	17.05	17.10	18.80	17.25	17.25	16.00	16.32	18.60	15.55	15.77
13	16.50	17.00	17.30	17.15	18.35	17.15	16.40	15.90	16.45	18.50	15.60	15.55
14	16.70	16.70	17.20	17.05	18.15	17.12	16.30	15.90	16.30	18.43	15.45	15.30
15	16.70	16.90	17.20	17.25	18.01	16.60	16.12	15.85	16.15	18.30	15.82	15.25
16	16.75	16.95	17.00	17.20	17.95	16.55	16.15	16.02	16.05	17.85	15.28	15.45
17	16.60	16.55	17.15	17.10	18.01	16.35	16.03	15.90	16.05	17.20	15.55	15.35
18	16.60	17.10	17.20	17.05	18.01	16.25	16.00	15.85	16.13	16.95	15.72	15.30
19	16.65	16.95	17.15	17.00	18.03	16.32	15.60	15.95	16.15	17.15	15.70	15.50
20	16.30	16.95	17.05	16.85	17.05	15.95	15.80	15.75	16.00	17.25	15.60	15.57
21	16.75	17.55	17.05	16.85	17.03	15.88	15.95	16.00	16.00	17.60	15.45	15.70
22	16.75	16.90	17.15	16.65	17.01	16.15	15.85	16.20	15.90	17.80	15.82	15.72
23	16.75	17.00	16.85	17.20	17.04	15.95	15.80	15.35	15.95	17.75	15.27	15.68
24	16.65	16.60	17.15	17.20	17.06	16.35	15.70	16.45	15.95	17.75	15.55	15.60
25	16.70	17.00	16.95	18.00	18.40	16.55	15.85	16.65	16.40	17.85	15.72	15.65
26	16.70	16.90	16.95	18.40	19.00	16.70	16.15	16.45	16.40	17.75	15.70	15.70
27	16.45	17.00	16.95	18.45	19.40	16.95	16.76	16.45	16.40	17.65	15.55	16.10
28	16.65	16.95	17.15	18.50	19.30	17.05	16.75	16.20	16.45	17.55	15.40	15.75
29	16.60	16.95	17.05	18.50	18.80	17.05	15.70	16.10	16.40	17.65	14.95	15.80
30	16.75	.....	16.45	18.90	18.40	17.20	15.25	16.27	16.45	17.70	15.55	16.30
31	16.65	.....	17.20	.....	17.80	.....	15.55	16.15	.....	17.22	.....	16.40

[a] Frozen from January 1 to March 30, when ice begins to break. Ice varied rom 6 to 18 inches in thickness.
[b] Ice conditions March 31 to about April 10.
[c] Ice conditions during December.
[d] Weight gone.
[e] Key lost. No gage height taken on August 3 and 4.

Rating table for Flambeau River near Ladysmith, Wis., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
15.0	567	16.0	1,399	17.0	2,841	18.4	5,291
15.1	596	16.1	1,542	17.1	2,990	18.6	5,704
15.2	637	16.2	1,686	17.2	3,143	18.8	6,120
15.3	690	16.3	1,830	17.3	3,300	19.0	6,539
15.4	755	16.4	1,974	17.4	3,461	19.2	6,959
15.5	832	16.5	2,118	17.5	3,626	19.4	7,379
15.6	921	16.6	2,262	17.6	3,795	19.6	7,799
15.7	1,022	16.7	2,406	17.8	4,145	19.8	8,219
15.8	1,135	16.8	2,550	18.0	4,511	20.0	8,639
15.9	1,260	16.9	2,695	18.2	4,893		

The foregoing table is applicable only for open-channel conditions. It is based upon fourteen discharge measurements made during 1903 and 1904. It is well defined between gage heights 16 feet and 19 feet. The table has been extended beyond these limits. Above gage height 18.9 feet the rating curve is a tangent, the difference being 210 per tenth.

Estimated monthly discharge of Flambeau River near Ladysmith, Wis., for 1904.

[Drainage area, 2,120 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
April [a]	6,339	2,334	3,389	1.60	1.78
May	7,379	2,856	5,183	2.44	2.81
June	5,034	1,234	2,890	1.36	1.52
July	8,429	662	2,834	1.34	1.54
August [b]	2,334	607	1,336	.630	.726
September	4,109	1,260	2,056	.970	1.08
October [b]	5,912	1,470	3,517	1.66	1.91
November	3,300	555	1,416	.668	.745
December [a]	1,974	390	951	.449	.518

[a] Estimates April and December made as if open channel.
[b] Discharge estimated for August 3 and 4 and October 1 to 4.

WISCONSIN RIVER DRAINAGE BASIN.

Wisconsin River is the largest river in the State of Wisconsin. It rises in the northern part and flows south through the central portion of the State to Portage, where it turns at nearly a right angle and flows west, emptying into the Mississippi about 60 miles above Dubuque.

Gaging stations were operated at Necedah and Merrill, Wis., during 1904.

WISCONSIN RIVER AT MERRILL, WIS.

This station was established November 17, 1902, by L. R. Stockman. It is located on the highway bridge in the city of Merrill, Wis., three blocks from the Lincoln County court-house, one-half mile from the Chicago, Milwaukee and St. Paul Railroad station, and 1,000 feet below the dam of the electric power house. Prairie River enters about one-half mile above the station and there is an island about 600 feet below. There is a vertical gage fastened to the mill abutment, from which part of the gage readings for 1903 have been made. June 17, 1903, a chain gage was established on the bridge and made to read the same as the old gage at the mill. It is fastened to the guard timber on the downstream side, and the zero is marked by a brass screw driven into the guard timber. The fall of the water from the old to the new gage is 2.70 feet when the water is at a high

stage. The length of the chain from the end of the weight to the marker is 23.68 feet. The gage is read twice each day by A. F. Lueck. The initial point for soundings is a nail in the footboard at the left end of the bridge, opposite the center of the iron hand-rail post. This point is marked "zero." Discharge measurements are made from the two-span highway bridge, to which the chain gage is fastened. Each span of the bridge is 175 feet in length. The channel is straight from the dam above to the bridge and for about 400 feet below. The velocity is rapid and the surface rough. The station is so near the dam that at high stages the velocity is affected, and it is possible that the bed of the stream may be subject to slight change, although it is of rock and gravel and is very rough. The channel is about 300 feet wide at low stages and 400 feet wide at high water. Both banks are high and do not overflow. Bench mark No. 1 is a cross cut in the sandstone rock in the bridge seat of the abutment nearest to the city. Its elevation above the zero of the gage is 16.25 feet. This bench mark is 18.28 feet below the United States bench mark located at the corner of the engine house opposite the city hall.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Wisconsin River at Merrill, Wis., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Sq. feet.*	*Feet per sec.*	*Feet.*	*Sec.-feet.*
January 20 [a]	L. R. Stockman	310	718	1.91	4.05	1,376
February 16 [a]	do	310	669	1.86	3.70	1,250
March 20	do	344	2,639	3.78	8.90	9,995
May 7 [b]	do	332	2,232	3.54	6.85	7,893
June 17 [b]	do	308	1,269	1.78	4.72	2,258
July 13	do	305	1,424	2.10	5.70	2,993
August 22 [b]	do	283	1,115	2.36	5.00	2,638
September 11	E. C. Murphy	343	1,759	3.19	6.66	5,614
October 24	L. R. Stockman	334	1,594	2.61	6.08	4,159
1904.						
May 12 [b]	E. Johnson, jr	334	2,220	3.71	7.85	8,242
June 5	do	334	2,286	4.19	8.25	9,587
July 15 [b]	do	334	1,366	1.98	5.30	3,107
September 21	do	312	1,210	1.91	5.01	2,312
October 14	F. W. Hanna	327	2,333	4.42	8.25	10,320
November 30 [a]	E. Johnson, jr	306	1,237	1.85	4.97	2,294

[a] Partly frozen.

[b] Effected by log jam.

Mean daily gage height, in feet, of Wisconsin River at Merrill, Wis., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.90	5.65	5.90	5.90	7.55	7.55	6.75	5.15	5.05	6.15	6.70	4.85
2	6.00	5.65	5.95	5.85	7.10	7.25	6.80	5.20	4.90	6.25	6.60	5.20
3	6.05	5.60	5.90	5.90	6.80	7.30	6.60	5.10	5.95	6.70	6.25	4.85
4	6.10	5.55	5.90	5.85	7.05	7.70	6.20	5.00	7.80	5.85	5.90	4.85
5	6.10	5.70	5.90	5.90	7.30	8.05	6.25	5.05	6.90	6.40	5.75	4.75
6	6.00	5.70	5.85	6.40	6.75	8.30	6.20	5.25	6.25	5.90	5.70	4.95
7	5.75	5.60	5.95	6.35	6.75	7.80	6.20	5.20	7.05	5.60	5.55	4.80
8	5.80	5.80	5.85	6.65	7.05	7.85	6.35	6.65	7.00	6.70	5.15	5.15
9	5.50	5.80	5.90	7.20	8.40	7.55	6.70	5.10	6.75	7.75	4.70	5.00
10	5.85	5.75	5.90	7.15	8.20	7.35	6.95	5.20	5.90	10.10	4.55	5.00
11	5.55	5.85	5.90	7.15	7.90	7.00	7.20	5.30	6.15	10.40	4.40	4.65
12	5.70	5.75	5.90	6.75	7.95	7.55	6.55	6.20	6.60	10.15	4.75	4.45
13	5.75	6.10	5.80	6.80	7.70	7.25	5.45	7.15	6.15	9.05	5.90	4.80
14	5.70	5.55	5.80	6.65	7.95	6.50	6.00	5.50	5.95	8.30	6.00	5.05
15	5.55	5.60	5.90	6.35	7.70	6.20	5.75	5.30	5.95	7.55	4.60	5.20
16	5.60	5.65	5.85	5.85	7.90	6.10	5.60	5.70	5.90	7.15	4.50	5.30
17	5.60	5.95	5.90	6.45	7.40	6.05	5.80	6.65	5.90	6.90	4.55	5.20
18	5.55	5.90	5.75	6.30	6.55	6.10	6.05	5.90	5.95	6.90	4.55	5.20
19	5.65	5.90	5.65	6.35	6.75	6.50	4.50	5.75	5.90	6.95	4.75	5.10
20	5.60	6.15	5.70	6.15	6.75	6.20	4.60	6.40	5.20	6.25	5.05	5.05
21	5.70	5.85	5.75	6.05	6.85	6.05	5.10	6.10	5.35	6.35	5.10	5.20
22	5.65	5.95	5.80	6.05	7.05	6.10	5.20	6.20	5.05	6.80	5.25	5.70
23	5.60	5.90	5.35	6.10	7.05	6.05	5.30	6.15	5.50	6.65	5.10	5.25
24	5.50	5.90	5.75	7.00	7.05	7.25	4.90	5.85	6.80	6.55	4.95	5.20
25	5.85	5.90	6.00	8.10	8.10	5.60	4.50	5.80	7.10	7.10	4.75	5.45
26	5.55	5.90	5.85	8.35	10.10	6.00	4.60	5.70	7.75	7.20	4.95	5.05
27	5.55	5.90	5.55	8.45	10.60	6.25	5.40	6.00	7.15	6.90	5.45	5.60
28	5.55	5.90	5.70	8.50	9.80	7.25	5.10	5.50	7.20	6.75	5.15	5.95
29	5.55	5.95	5.80	8.20	9.05	6.80	5.50	5.90	6.40	6.85	5.15	5.60
30	5.55	.....	5.70	7.75	8.60	6.30	5.70	6.35	6.10	6.65	4.85	5.50
31	5.50	.....	5.80	.....	7.95	.....	5.50	5.05	.....	6.25	.....	5.15

Rating table for Wisconsin River at Merrill, Wis., from June 17, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
4.5	1,485	5.5	3,225	6.5	5,485	8.0	9,565
4.6	1,645	5.6	3,425	6.6	5,725	8.2	10,225
4.7	1,805	5.7	3,635	6.7	5,975	8.4	10,885
4.8	1,970	5.8	3,855	6.8	6,225	8.6	11,545
4.9	2,140	5.9	4,075	6.9	6,475	8.8	12,205
5.0	2,310	6.0	4,305	7.0	6,725	9.0	12,865
5.1	2,485	6.1	4,535	7.2	7,245	9.5	14,515
5.2	2,665	6.2	4,765	7.4	7,785	10.0	16,165
5.3	2,845	6.3	5,005	7.6	8,345	10.5	17,815
5.4	3,035	6.4	5,245	7.8	8,935	11.0	19,465

The above table is applicable only for open-channel conditions. It is based upon 17 discharge measurements made during 1902 to 1904, inclusive. It is not well defined. Above gage height 8 feet the rating curve is a tangent, the difference being 330 per tenth.

Estimated monthly discharge of Wisconsin River at Merrill, Wis., for 1904.

[Drainage area, 2,630 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	4,535	3,225	3,664	1.39	1.60
February	4,655	3,330	3,749	1.43	1.66
March	4,305	2,945	3,889	1.48	1.71
April	11,220	3,970	6,242	2.37	2.64
May	18,140	5,610	8,935	3.40	3.92
June	10,560	3,425	6,472	2.46	2.74
July	7,245	1,485	3,957	1.51	1.74
August	7,110	2,310	3,766	1.43	1.65
September	8,935	2,140	5,000	1.90	2.12
October	17,480	3,425	7,343	2.79	3.22
November	5,975	1,410	2,800	1.06	1.18
December	4,195	1,490	2,566	.976	1.12
The year	18,140	1,410	4,865	1.85	25.15

WISCONSIN RIVER NEAR NECEDAH, WIS.

This station was established December 2, 1902, by L. R. Stockman. It is located on the highway toll bridge 3 miles east of Necedah, Wis., and 3 miles from the Chicago, Milwaukee and St. Paul and Chicago and Northwestern Railroad stations. Yellow River flows into the Wisconsin about 4 miles below the station. There are islands both above and below the station, but they are several hundred feet away. A regulation chain gage is fastened to the upstream side of the highway bridge. The length from the end of the weight to the marker is 26.87 feet. The gage is read daily by W. F. Bingman. Discharge measurements are made from the two-span highway bridge to which the gage is attached. The initial point for soundings is a point over the right abutment, marked by a nail in the floor of the bridge and also marked "zero" with paint. The general direction of the channel is straight for 2,000 feet above and below the station. The velocity is rapid and rather poorly distributed on account of an ice breaker above the middle pier and the variation in width of the channel just above the bridge. The width of the channel at ordinary stages is about 325 feet, broken by one pier. The right bank is high and rocky; the left bank overflows, making the width of the channel from 500 to 600 feet. During the spring floods of 1903 the water overflowed the turnpike.

The right side of the bed of the stream is rocky, but the remainder is sandy and liable to shift.

Bench mark No. 1 is a nail in the top of a red-oak stump, 2½ feet in diameter, about 60 feet south of the center of the roadbed and about 50 feet from the river at ordinary stages. Its elevation above the zero of the gage is 12.99 feet. Bench mark No. 2 is a nail in the root of a large cottonwood tree, 280 feet south of the bridge and about 80 feet from the river. Its elevation above the zero of the gage is 11.90 feet. Bench marks Nos. 1 and 2 are on the east side of the river. Bench mark No. 3 is a cross on a large sandstone rock, 70 feet south of the center of the roadway and 15 feet west of the water's edge on the west bank of the river. Its elevation above the zero of the gage is 20.36 feet.

The drainage area at this station is 5,800 square miles.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Wisconsin River near Necedah, Wis., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Sq. feet.*	*Feet per sec.*	*Feet.*	*Sec.-feet.*
January 13[a]	L. R. Stockman	280	2,617	1.18	5.65	2,840
February 5[a]	do	284	2,360	1.26	5.80	2,585
March 5[a]	do	284	2,411	1.09	5.80	2,422
March 26	Johnson and Stockman.		5,405	3.94	11.05	21,280
April 2	L. R. Stockman	220	4,206	2.42	7.55	10,190
April 28	do	309	3,860	1.84	6.50	7,123
June 12	do	281	3,282	1.79	6.00	5,888
July 7	do	316	4,708	4.43	10.50	20,860
August 19	do	302	2,832	2.46	6.20	6,962
September 4	do	276	2,463	2.05	5.30	5,047
October 12	do	314	3,871	3.23	9.43	12,500
1904.						
January 12[a]	E. Johnson, jr	286	2,031	1.33	4.60	3,000
May 11	do	317	4,685	3.65	9.60	17,110
May 23	Johnson and Hanna	314	3,717	2.67	7.05	9,921
July 16	E. Johnson, jr	294	3,525	1.66	5.80	5,845
September 21	do	294	1,823	2.08	4.92	3,800
October 14	F. W. Hanna	449	6,216	5.71	13.35	[b] 34,420

[a] Frozen.

[b] Add to this discharge 3,000 second-feet overflow.

Mean daily gage height, in feet, of Wisconsin River near Necedah, Wis., for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.[a]	Apr.[b]	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.[c]
1	6.0	5.1	5.3	6.60	9.80	11.20	6.30	4.50	4.80	6.60	7.10	4.80
2	5.7	5.2	5.3	6.30	9.20	10.00	6.50	4.70	4.80	6.45	6.90	4.80
3	5.9	5.1	5.3	6.50	8.90	9.10	6.50	4.90	4.80	6.20	6.60	4.80
4	5.6	5.0	5.3	6.90	8.40	8.60	6.30	4.80	4.80	6.10	6.70	.....
5	6.0	5.2	5.3	6.60	8.00	8.40	6.20	4.70	4.30	7.00	6.50	.....
6	6.0	5.2	5.3	6.80	7.80	9.00	6.30	4.70	5.80	6.00	6.40	.....
7	5.9	5.2	5.3	7.00	7.40	9.90	6.00	4.30	6.30	5.90	6.10	.....
8	6.1	5.0	5.4	7.20	.....	10.50	5.90	4.40	5.90	6.30	6.10	.....
9	6.1	5.2	5.4	7.50	7.40	10.50	6.10	4.80	5.70	6.42	6.60	.....
10	6.0	4.9	5.3	7.90	7.90	9.80	6.30	4.90	5.70	6.70	6.10	5.10
11	5.9	5.1	5.3	8.80	9.50	9.00	6.40	5.30	5.30	8.40	5.90	.....
12	5.1	5.2	5.3	9.80	10.50	8.30	6.80	5.30	5.70	10.10	5.20	.....
13	5.1	5.1	5.3	9.80	10.50	7.80	7.10	5.40	5.30	12.00	5.50	.....
14	5.2	5.2	5.2	9.40	9.90	7.50	7.00	5.30	5.50	13.20	5.50	...
15	5.2	5.1	5.3	8.70	9.40	7.20	6.50	5.30	5.60	13.00	5.60	.....
16	5.3	5.2	5.2	8.30	9.20	6.80	5.90	5.70	4.90	11.90	5.80	.....
17	5.2	5.2	5.2	7.70	9.00	6.90	5.80	5.00	5.20	10.30	5.50	5.50
18	5.1	5.1	5.2	7.30	8.50	6.70	5.50	5.10	5.30	9.40	5.30	.....
19	5.3	5.1	5.1	7.50	8.00	6.50	5.80	5.00	5.90	9.00	4.80	.....
20	5.0	5.0	5.0	7.50	7.70	6.20	5.50	5.00	5.70	8.40	5.00	.....
21	5.2	5.1	4.9	7.70	7.40	5.90	5.60	5.00	4.80	7.90	5.00	.....
22	5.2	5.1	5.0	7.70	7.20	5.80	5.30	4.70	4.90	8.00	5.30	.....
23	5.2	5.1	5.0	7.50	7.10	6.20	5.00	5.10	4.80	8.50	5.40	.....
24	5.1	5.1	4.8	7.60	7.00	5.70	4.80	4.80	4.70	8.50	5.30	5.10
25	5.0	5.2	5.0	8.00	7.50	6.00	4.50	4.90	4.85	8.30	4.90	.....
26	5.1	5.3	5.0	9.30	8.10	5.70	4.80	4.90	4.80	8.30	5.50	.....
27	5.0	5.4	5.2	10.30	9.40	6.10	4.90	5.00	6.70	7.90	5.10	.....
28	5.1	5.2	5.2	10.90	10.60	5.80	4.80	5.90	7.40	7.60	4.80	.....
29	5.2	5.1	5.2	10.70	11.90	6.10	4.70	4.60	7.40	7.50	5.00	.....
30	5.2	.....	5.5	10.50	12.60	6.00	4.80	5.00	7.00	7.40	5.00	.....
31	5.1	.....	5.8	.....	12.30	.....	4.70	4.70	.....	7.00	.....	5.00

[a] River frozen from January 1 to March 31. Ice, average thickness, 10 inches.
[b] Ice conditions April 1 to 12.
[c] Frozen December 4 to 31. Ice 0.1 foot to 2 feet thick.

Rating table for Wisconsin River near Necedah, Wis., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
4.0	1,800	5.1	4,150	6.4	7,600	9.5	16,900
4.1	2,000	5.2	4,390	6.6	8,200	10.0	18,400
4.2	2,200	5.3	4,630	6.8	8,800	10.5	19,900
4.3	2,400	5.4	4,880	7.0	9,400	11.0	21,400
4.4	2,600	5.5	5,130	7.2	10,000	11.5	23,610
4.5	2,810	5.6	5,380	7.4	10,600	12.0	25,860
4.6	3,020	5.7	5,640	7.6	11,200	12.5	28,230
4.7	3,240	5.8	5,900	7.8	11,800	13.0	30,750
4.8	3,460	5.9	6,170	8.0	12,400	13.5	38,450
4.9	3,690	6.0	6,440	8.5	13,900		
5.0	3,920	6.2	7,010	9.0	15,400		

The foregoing table is applicable only for open-channel conditions. It is based upon 19 discharge measurements made during 1902 to 1904, inclusive. It is well defined between gage heights 4.5 feet and 10.5 feet. The table has been extended beyond these limits. From gage height 6.3 feet to 11 feet the rating curve is a tangent, the difference being 300 per tenth. The bank overflows at gage height about 11 feet, which accounts for the suddenness and magnitude of the increase in difference per tenth.

Estimated monthly discharge of Wisconsin River near Necedah, Wis., for 1904.

[Drainage area, 5,800 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
April	21,100	7,300	12,830	2.21	2.47
May	28,720	9,400	15,250	2.63	3.03
June	22,280	5,640	11,350	1.96	2.19
July	9,700	2,810	5,926	1.02	1.18
August	6,170	2,400	3,845	.663	.764
September	10,600	2,400	5,227	.901	1.01
October	33,830	6,170	13,590	2.34	2.70
November	9,700	3,460	5,698	.982	1.10

ROCK RIVER DRAINAGE BASIN.

Rock River, with its tributaries, Pecatonica and Kishwaukee rivers, is one of the most important streams in Illinois. It rises in the southeastern part of Wisconsin, flows south and southwest, and enters the Mississippi just below Rock Island, Ill. This river has much power already developed along its course, and there are several points at which large water-power plants could be situated. It is also to be used as a feeder for the Hennepin canal. The United States Geological Survey has maintained a station on this river at Rockton, Ill., below the mouth of Pecatonica River during the year of 1904.

ROCK RIVER AT ROCKTON, ILL.

This station was established May 13, 1903, by E. Johnson, jr., assisted by L. R. Stockman. It is located at the village highway bridge, one-half mile from the Chicago, Milwaukee and St. Paul Railroad station, 1 mile below the dam and three-fourths of a mile below the junction of Pecatonica River with Rock River. There are small islands a short distance above and immediately below the station. The chain gage is located on the first span from the left end of the bridge, on the downstream side. The gage is read twice each day by

O. T. Bartholomew. The length from end of weight to marker is 26.45 feet. Discharge measurements are made from the upstream side of the five-span highway bridge to which the gage is attached. The initial point for soundings is the face of the abutment on the left end of the bridge. The channel is straight for 2,000 feet above and 1,000 feet below the station. Both banks are high and will not overflow. The channel is about 565 feet wide between bridge abutments and is broken by four piers. The bed of the stream is composed of small rocks and gravel.

Bench mark No. 1 is a hammered cross on the top stone of the left abutment, about 1 foot from the bridge shoe and 1 foot from the south edge. Its elevation above gage datum is 16.85 feet. Bench mark No. 2 is the top of the west end of the south rail of the railroad track, 250 feet north of the north end of the bridge, at a point where the sidewalk on the west side of the street crosses the track. Its elevation above gage datum is 16.49 feet.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Rock River at Rockton, Ill., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Sq. feet.*	*Feet per sec.*	*Feet.*	*Sec.-ft.*
May 13	L. R. Stockman	.....	.....	.....	2.90	2,522
June 30	A. C. Lootz	296	547	2.74	2.30	1,501
August 18	L. R. Stockman	490	1,352	3.41	4.07	4,611
September 4	F. W. Hanna	.....	1,352	3.41	4.08	4,607
October 9	do	504	1,998	3.74	5.35	7,464
November 9	do	453	831	[a] 3.46	2.85	2,874
December 10[b]	do	367	743	3.21	2.60	2,384
1904.						
January 16[c]	F. W. Hanna	380	662	2.25	2.90	1,487
March 14	do	509	4,031	2.77	9.30	11,180
March 25	do	509	5,744	4.34	12.32	24,910
April 18	do	504	2,361	3.90	5.91	9,212
June 23	do	378	660	3.18	2.50	2,099
July 7	do	389	645	2.93	2.38	1,889
August 30	do	381	674	3.02	2.45	2,034
September 23	do	408	739	3.19	2.65	2,355
October 26	do	426	759	3.13	2.70	2,372
November 9	do	397	695	3.09	2.50	2,149

[a] High wind; velocity doubtful. [b] Partly frozen. [c] Ice 0.59 foot thick.

Mean daily gage height, in feet, of Rock River at Rockton, Ill., for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.[a]	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.[a]
1	2.90	2.90	3.80	10.65	4.53	3.68	2.20	2.10	2.15	3.50	2.65	2.20
2	2.90	2.90	3.95	9.61	4.50	3.68	2.20	1.90	2.15	3.25	2.60	2.15
3	2.90	3.10	6.09	8.85	4.30	3.51	2.25	1.80	2.20	3.15	2.45	2.20
4	3.00	3.20	6.72	8.37	4.18	3.00	2.20	1.80	2.12	3.00	2.50	2.20
5	2.90	3.00	6.83	8.06	4.05	3.20	2.15	1.80	2.30	2.85	2.45	2.25
6	2.80	2.80	6.60	7.85	4.01	3.10	2.15	1.90	2.60	3.20	2.45	2.20
7	2.90	4.50	7.45	7.60	4.00	3.10	2.30	1.95	2.45	3.25	2.25	2.20
8	2.90	5.50	9.92	7.60	4.18	3.11	2.40	1.90	2.35	3.10	2.45	2.20
9	2.90	5.90	10.80	7.60	4.50	3.00	2.50	1.82	2.30	2.75	.....	2.20
10	3.00	6.10	11.12	7.60	4.85	2.95	2.46	1.90	2.31	3.00	2.45	2.20
11	2.60	6.00	11.10	7.61	4.79	2.95	2.35	1.85	2.30	3.40	2.45	2.20
12	2.90	5.80	10.90	7.41	4.76	2.85	2.35	1.75	2.20	3.81	2.50	2.20
13	2.90	5.50	10.30	7.10	4.81	2.80	2.40	1.80	2.20	4.25	2.40	2.40
14	3.00	4.70	9.33	6.83	4.81	2.75	2.25	1.70	2.26	4.25	2.20	2.45
15	2.80	4.10	8.85	6.50	4.91	2.70	2.20	1.85	2.20	4.50	2.30	2.70
16	2.90	3.90	8.00	6.40	4.95	2.60	2.13	1.55	2.15	3.80	2.45	2.85
17	3.00	3.80	6.34	6.20	4.99	2.62	2.00	1.75	2.10	3.30	2.45	2.70
18	2.70	3.80	5.50	5.91	4.81	2.55	2.10	1.90	2.20	3.15	2.35	3.00
19	3.00	3.60	4.90	5.79	4.80	2.65	2.10	1.75	2.90	3.50	2.45	2.65
20	3.00	3.60	8.35	5.60	4.68	2.50	2.10	1.90	4.00	2.90	2.40	2.90
21	3.10	3.70	8.35	5.48	4.60	2.50	2.00	1.95	3.80	2.75	2.20	2.80
22	3.10	3.60	12.75	5.35	4.48	2.50	2.00	2.50	3.25	2.70	2.30	2.70
23	3.20	3.50	13.23	5.16	4.32	2.50	2.00	2.80	2.80	2.70	2.30	2.45
24	3.30	3.80	12.05	5.18	4.28	2.45	2.00	3.00	2.55	2.75	2.20	2.50
25	3.20	3.50	12.25	5.53	4.31	2.40	1.75	3.10	2.35	2.70	2.30	2.50
26	3.30	3.50	12.55	5.56	4.18	2.35	2.10	2.70	2.65	2.65	2.40	2.50
27	3.30	3.60	12.40	5.31	4.10	2.15	2.50	2.30	3.35	2.65	2.20	3.00
28	3.10	3.60	12.30	5.04	3.90	2.20	2.10	2.40	4.20	2.70	2.20	4.20
29	3.00	3.80	11.85	4.80	3.85	2.20	2.00	2.10	4.12	2.60	2.20	5.10
30	2.90	.....	11.45	4.63	3.79	2.20	2.00	2.20	3.65	2.55	2.30	5.15
31	2.90	.....	11.16	.....	3.80	.....	2.00	2.30	.....	2.75	.....	4.60

[a] River partially frozen January 1 to March 27, and December 13 to 31.

Rating table for Rock River at Rockton, Ill., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.5	810	2.8	2,470	4.2	4,940	8.0	14,020
1.6	910	2.9	2,620	4.4	5,345	8.5	15,270
1.7	1,015	3.0	2,775	4.6	5,760	9.0	16,520
1.8	1,125	3.1	2,935	4.8	6,180	9.5	17,770
1.9	1,235	3.2	3,105	5.0	6,620	10.0	19,020
2.0	1,350	3.3	3,280	5.2	7,070	10.5	20,270
2.1	1,470	3.4	3,455	5.4	7,540	11.0	21,520
2.2	1,600	3.5	3,635	5.6	8,020	11.5	22,770
2.3	1,740	3.6	3,815	5.8	8,520	12.0	24,020
2.4	1,880	3.7	3,995	6.0	9,020	13.0	26,520
2.5	2,025	3.8	4,180	6.5	10,270		
2.6	2,170	3.9	4,365	7.0	11,520		
2.7	2,320	4.0	4,555	7.5	12,770		

The preceding table is applicable only for open-channel conditions. It is based upon 17 discharge measurements made during 1903 and 1904. It is well defined between gage heights 2.4 feet and 6 feet. One flood measurement at 12.32 fixes the upper part of the curve. The table has been extended beyond these limits. Above gage height 5.6 feet the rating curve is a tangent, the difference being 250 per tenth.

Estimated monthly discharge of Rock River at Rockton, Ill., for 1904.

[Drainage area, 6,150 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January [a]	3,280	2,170	2,747	0.446	0.514
February [a]	9,270	2,470	4,762	.774	.835
March [a]	27,100	4,180	17,220	2.80	3.23
April	20,640	5,823	10,810	1.76	1.96
May	6,598	4,162	5,405	.879	1.01
June	3,959	1,535	2,432	.395	.441
July	2,025	1,070	1,570	.255	.294
August	2,935	860	1,471	.239	.276
September	4,940	1,470	2,344	.381	.425
October	5,550	2,098	3,058	.497	.573
November	2,245	1,600	1,847	.300	.335
December [a]	6,955	1,535	2,514	.409	.472
The year	27,100	860	4,682	.761	10.37

[a] Daily discharges January, February, March, and December applied as for open channel.

ILLINOIS RIVER DRAINAGE BASIN.

Illinois River is formed by the junction of Kankakee and Desplaines rivers at a point near Minooka, Grundy County, Ill. Its principal tributaries are Fox and Spoon rivers from the west and Vermilion and Sangamon rivers from the east. During 1904 gaging stations have been maintained in the Illinois River drainage basin at Peoria, Ottawa, and Minooka on the Illinois, and on the Desplaines at Channahon above the mouth of Jackson Creek.

The drainage areas at the points where stations have been maintained are as follows:

Drainage areas in Illinois basin at gaging stations.

	Square miles.
ILLINOIS RIVER.	
Peoria	13,250
Minooka	6,480
Ottawa	10,100
DESPLAINES RIVER.	
Jackson Creek	1,170

ILLINOIS RIVER NEAR MINOOKA, ILL.

This station was established November 7, 1902, by E. H. Heilbron, to determine the flow of Kankakee River. It is 6 miles south of Minooka, Ill., and 2½ miles below the mouth of Kankakee River at the Elgin, Joliet and Eastern Railroad bridge. The gage is a vertical rod fastened to the center pier of the bridge. It is read twice daily by J. A. Lyons. Discharge measurements are made from the bridge. The initial point for soundings is an oak hub about 4 feet north of the north side of the railroad pumping station. The channel is straight for 1,000 feet above the station and 2,000 feet below. The width at ordinary stages is 560 feet, with a maximum depth of 12 feet. The flow is moderately rapid, but is sluggish at low stages. The width at high water is about 1,000 feet. The right bank is low and liable to overflow; the left bank is high. The bed of the stream is of gravel and is shifting on the north side.

The bench mark is a cut in the stone on the south abutment of the Elgin, Joliet and Eastern Railroad bridge. It is marked S. D. ⊡ P. B. M. Its elevation is 85.030 feet above the Hennepin datum and 66.764 feet below the Chicago city datum. The gage is set with its zero at the same elevation as the zero of the Chicago datum, thus giving directly the elevation of the river surface below this datum.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Illinois River near Minooka, Ill., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.[a]	Discharge.
1903.		*Feet.*	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec. feet.*
March 15	E. H. Heilbron	630	9,182	2.80	86.84	25,680
April 19	do	594	6,604	2.04	91.12	13,480
May 10	do	553	4,893	1.03	94.10	7,393
July 12	do	541	4,556	1.64	93.83	7,465
August 31	do	560	3,856	1.83	93.99	7,044
September 26	Johnson and Hanna.	520	4,199	1.75	94.10	7,319
October 24	do	530	4,317	1.78	94.10	7,673
November 11	F. W. Hanna	513	4,466	1.70	94.15	7,596
1904.						
March 26	E. H. Heilbron	948	14,800	4.40	78.50	64,880
March 27	do	682	12,980	3.85	79.98	50,920
April 3	do	622	11,230	3.30	82.40	37,120
April 17	do	580	6,937	2.44	89.63	16,930
April 26	do	584	7,740	2.62	88.15	20,310
May 2	do	560	6,454	2.46	90.51	15,890
May 19	do	565	5,140	1.91	93.00	9,845

[a] All gage heights are negative, being below Chicago datum.

Mean daily gage height, in feet, of Illinois River near Minooka, Ill., for 1904.[a]

Day.	Jan.[b]	Feb.[b]	Mar.[b]	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	91.89	90.20	83.71	81.60	90.00	92.76	94.65	94.65	.....	93.75	95.05	94.65
2	91.83	90.79	83.21	81.50	90.53	92.88	94.59	94.70	.....	93.75	95.05	94.60
3	91.79	90.80	81.36	82.37	91.02	92.95	94.65	94.70	94.58	94.20	94.92	94.60
4	91.85	90.80	81.75	83.17	91.42	93.10	.....	94.75	94.75	94.40	94.53	94.35
5	92.00	90.98	82.52	84.02	91.68	93.11	94.44	94.70	94.75	94.55	94.55	94.32
6	91.94	90.08	83.38	84.97	91.85	93.30	94.42	94.58	94.75	94.70	95.00	94.40
7	91.79	85.36	82.68	85.80	91.98	93.42	94.48	94.70	94.80	94.80	94.57	94.27
8	91.80	85.10	82.78	86.20	92.11	93.48	94.55	94.70	94.75	94.90	94.75	94.27
9	91.75	85.95	84.90	86.12	91.78	93.90	93.98	94.75	95.00	94.80	94.55	94.28
10	91.62	86.14	85.35	86.27	91.60	94.10	93.82	94.75	95.08	95.00	94.53	95.05
11	91.48	86.68	85.72	86.47	91.74	94.24	(c)	94.80	95.05	94.75	94.45	94.50
12	91.41	87.64	86.56	86.85	91.92	94.26	.....	94.70	95.00	94.90	94.55	94.25
13	91.81	88.49	87.58	87.41	92.25	94.36	.....	94.75	95.05	94.80	94.47	94.40
14	92.50	88.92	87.85	87.98	92.45	94.88	.....	94.87	95.15	94.95	94.48	94.35
15	92.09	89.67	88.48	88.42	92.56	94.68	.....	94.80	95.20	94.40	94.37	.....
16	91.87	90.08	88.52	89.17	92.68	94.27	.....	94.77	95.40	94.35	94.47	.....
17	91.89	90.12	88.54	89.65	92.90	94.76	.....	94.75	95.20	94.35	94.43	.....
18	91.80	90.45	88.51	90.02	92.92	94.65	.....	94.70	93.25	94.85	94.45	.....
19	91.91	90.76	85.21	90.30	93.03	94.60	.....	94.80	94.15	95.00	94.47	.....
20	91.49	90.67	82.80	90.85	93.12	94.72	.....	(c)	94.90	95.00	94.48	.....
21	86.95	90.70	83.37	91.15	93.29	94.68	.....	.....	95.10	95.05	94.52	.....
22	83.35	90.90	82.01	91.35	93.39	94.55	.....	.....	35.10	91.90	94.52	.....
23	83.40	90.95	80.66	91.48	93.34	94.90	.....	.....	95.20	95.10	94.48	.....
24	84.90	90.88	81.21	90.60	93.47	95.02	.....	.....	95.05	95.10	94.53	.....
25	85.65	90.89	79.52	90.42	93.44	94.92	.....	.....	95.00	95.00	94.45	.....
26	86.14	90.81	78.50	88.82	93.46	94.85	.....	.....	94.55	95.00	94.45	.....
27	87.24	90.62	80.02	87.08	93.55	95.00	.....	.....	94.70	95.00	95.20	.....
28	88.38	90.53	81.25	87.50	93.51	94.84	.....	.....	93.95	94.05	95.30	.....
29	89.11	88.65	82.24	88.27	93.50	94.76	.....	.....	92.85	95.07	95.07	.....
30	89.45	.....	83.12	89.22	93.28	94.62	.....	.....	93.60	94.95	94.95	.....
31	89.73	.....	82.94	.....	92.96	.....	.....	.....	.....	95.05	.....	.....

[a] All gage heights here given of this river are below the Chicago datum.
[b] River frozen January 1 to about March 20. Ice varies in thickness from 0.5 to 2 feet.
[c] Observer absent.

Rating table for Illinois River near Minooka, Ill., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet*	*Feet.*	*Second-feet.*
95.0	6,320	93.5	8,735	91.0	13,530	86.5	24,590
94.9	6,470	93.4	8,905	90.8	13,950	86.0	26,040
94.8	6,620	93.3	9,075	90.6	14,370	85.5	27,550
94.7	6,770	93.2	9,245	90.4	14,800	85.0	29,120
94.6	6,925	93.1	9,415	90.2	15,240	84.5	30,750
94.5	7,080	93.0	9,590	90.0	15,680	84.0	32,440
94.4	7,240	92.8	9,950	89.8	16,120	83.5	34,200
94.3	7,400	92.6	10,330	89.6	16,560	83.0	36,000
94.2	7,560	92.4	10,710	89.4	17,020	82.5	37,880
94.1	7,720	92.2	11,110	89.2	17,480	82.0	39,820
94.0	7,885	92.0	11,510	89.0	17,960	81.0	44,010
93.9	8,055	91.8	11,910	88.5	19,210	80.0	49,910
93.8	8,225	91.6	12,310	88.0	20,510	79.0	59,010
93.7	8,395	91.4	12,710	87.5	21,820		
93.6	8,565	91.2	13,110	87.0	23,180		

The preceding table is applicable only for open-channel conditions. It is based upon 16 discharge measurements made during 1903 and 1904. It is well defined between gage heights −94 feet and −87 feet. All gage heights are negative, being below Chicago datum. The table has been extended beyond these limits. Above gage height −79.5 feet the rating curve is a tangent, the difference being 1,200 per tenth.

Estimated monthly discharge of Illinois River near Minooka, Ill., for 1904.

[Drainage area, 6,480 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
March 21–31	64,810	34,670	44,130	6.81	2.79
April	41,860	12,510	22,610	3.49	3.89
May	15,680	8,565	10,660	1.65	1.90
June	9,950	6,320	7,559	1.17	1.30
July 1–10	8,225	6,925	7,245	1.12	.417
August 1–19	6,925	6,470	6,699	1.03	.728
September 3–30	9,950	5,720	6,772	1.05	1.09
October	8,225	6,170	6,735	1.04	1.20
November	7,240	5,870	6,848	1.06	1.18
December 1–14	7,560	6,320	7,164	1.11	.578

ILLINOIS RIVER AT OTTAWA, ILL.

This station was established November 11, 1902, by E. H. Heilbron. It is located at the Chicago, Burlington and Quincy Railroad bridge, 2,500 feet below the mouth of Fox River and 200 feet below the highway bridge leading to the main street of Ottawa, Ill. A standard chain gage was established November 1, 1903, to replace the old vertical gage and was made to read the same as the original gage. The length of chain from the end of the weight to the marker is 37.42 feet. The gage was read twice each day by D. C. Woods. Discharge measurements were made from the upper side of the railroad bridge, to which the gage is attached. The initial point for soundings was the center one of the group of nails driven into the cap at the left end of the trestlework, south of the main bridge structure. The channel is straight for about 2,000 feet above and below the station and has a width between abutments of 650 feet, broken by three piers. The depth at ordinary stages is about 13 feet. The railroad embankments form part of the banks of this river. The bed of the stream is composed of gravel, which is somewhat shifting. The flow is somewhat sluggish at low stages.

Bench mark No. 1 is the top of the coping stone at the east end of the first pier from the north end of the railroad bridge. The point is

marked "U. S." Its elevation is 48.638 feet above the Hennepin datum, and 103.156 feet below the Chicago datum. Bench mark No. 2 is a cut in the batter on the coign, 3 feet above ground, at the west end of the south pier of the railroad bridge. The gage is set with its zero at the same elevation as the zero of the Chicago datum, thus giving directly the elevation of the river surface below this datum.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Illinois River at Ottawa, Ill., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.[a]	Discharge.
1903.		*Feet.*	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
March 18	E. H. Heilbron	650	6,817	4.53	122.98	30,880
April 5	do	600	4,738	3.71	126.25	17,570
April 28	do	610	5,001	3.67	126.07	18,340
May 12	do	545	3,501	3.32	128.42	11,620
July 8	do	480	2,847	2.65	129.54	7,541
August 23	E. Johnson, jr	660	2,924	2.62	129.57	7,668
September 25	Johnson and Hanna	560	3,466	3.35	128.35	11,590
October 12	do	553	3,609	3.75	127.88	13,540
November 12	F. W. Hanna	525	3,090	2.88	129.01	8,898
December 12[b]	do	550	4,424	1.54	126.42	6,822
1904.						
March 30	E. H. Heilbron	745	10,220	4.56	118.30	46,560
April 2	do	750	10,990	4.96	117.30	54,470
April 17	do	626	5,164	3.62	125.40	18,720
April 26	do	652	6,136	4.20	123.90	25,920
May 2	do	608	4,775	3.90	125.80	18,610
May 19	do	541	3,583	2.89	128.1	10,340

[a] Below Chicago datum. [b] Ice jam.

Mean daily gage height,[a] in feet, Illinois River at Ottawa, Ill., for 1904.

Day.	Jan.	Feb.	Day.	Jan.	Feb.	Day.	Jan.	Feb.	Day.	Jan.	Feb.
1	127.28	124.20	9	126.82	120.00	17	127.02	124.60	25	120.00	.....
2	127.22	124.20	10	126.80	120.30	18	126.95	124.80	26	120.50	.....
3	127.12	124.20	11	126.88	120.70	19	126.90	124.10	27	121.00	.....
4	126.90	124.20	12	126.85	121.30	20	125.30	124.10	28	122.10	.....
5	126.82	124.20	13	126.90	122.70	21	121.10	124.11	29	122.22	.....
6	126.80	123.45	14	126.98	123.10	22	118.60	.....	30	123.20	.....
7	126.80	120.60	15	127.24	123.60	23	118.80	.....	31	123.92	.....
8	126.85	118.60	16	127.32	123.80	24	119.45	.....			

[a] The gage heights here given of this river are below the Chicago datum and were recorded on the cards as minus (−).

ILLINOIS RIVER NEAR PEORIA, ILL.

This station was established March 10, 1903, by E. H. Heilbron. It is located on the Peoria and Pekin Union Railroad bridge over the Illinois River, 1½ miles southwest of Peoria, Ill., and can be reached by street cars. The gage is a plain staff graduated to feet and inches and fastened to the central pier of the bridge. It is read twice daily by the draw tender of the bridge, P. A. Blumb. The measurements are taken from the bridge, and the initial point for sounding is on the right bank. The river is straight for 3,000 feet above and 2,000 feet below the station and has a width of about 1,000 feet, broken by six piers. The section is deep and the flow sluggish. The bed of the stream is composed of gravel and silt. The right bank is high, and there is a railroad embankment along this shore. The left bank is low and liable to overflow.

The bench mark is the southwest corner of the top stone of the west abutment of the bridge; elevation, 125.722 feet below the Chicago datum. The gage at this point has for its zero a point 153.814 feet below the Chicago city datum. The gage reads up from this point, and in order to obtain the height of the river, referred to the Chicago datum, it is necessary to subtract the gage reading from 153.814 feet.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Illinois River near Peoria, Ill., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second ft.*
January 30[a]	E. H. Heilbron	943	14,870	1.58	16.30	21,120
February 4[a]	do	933	13,640	1.20	15.42	16,300
February 14	do	955	14,810	1.50	16.30	21,780
March 3	do	953	13,300	1.75	14.94	23,280
March 28	do	951	19,980	2.93	21.83	58,370
March 31	do	953	20,250	2.21	21.48	[b]44,810
April 2	do	953	19,310	2.17	21.17	[b]41,930
April 7	do	953	19,030	2.71	20.12	51,560
April 9	do	953	18,570	2.87	19.66	52,370
April 16	do	953	16,870	2.46	18.00	41,460
April 24	do	946	14,080	1.96	15.70	27,590
May 1	do	952	14,460	2.16	16.00	31,310
May 18	do	950	11,830	1.43	13.21	16,910

[a] Partly frozen.

[b] Questionable.

Mean daily gage height, in feet, of Illinois River near Peoria, Ill., for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.[a]	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.[b]
1	10.12	15.86	14.17	21.29	15.96	11.67	8.42	8.46	8.04	9.58	7.83	7.58
2	10.25	15.71	14.37	21.17	15.75	11.54	8.04	8.42	7.96	9.67	7.83	7.58
3	10.25	15.54	14.79	21.08	15.54	11.46	7.88	8.33	8.00	9.63	7.83	7.50
4	10.25	15.37	15.54	20.87	15.42	11.62	7.71	8.25	7.96	9.50	7.75	7.50
5	10.25	15.21	16.12	20.62	15.12	11.38	.....	8.21	7.83	9.58	7.79	7.50
6	10.17	15.33	16.67	20.46	14.87	11.29	8.04	8.12	7.78	9.46	7.75	7.50
7	10.17	15.50	16.87	20.12	14.75	11.17	7.95	8.00	7.75	9.29	7.67	7.54
8	10.17	15.62	17.04	19.79	14.54	11.17	7.92	7.92	7.63	9.17	7.75	7.62
9	10.17	15.92	17.25	19.67	14.37	11.38	8.12	7.75	7.46	9.17	7.75	7.79
10	10.17	16.29	17.67	19.46	14.29	11.46	8.12	7.83	7.38	9.08	7.75	7.83
11	10.17	16.42	17.87	19.21	14.04	11.25	8.16	7.75	7.58	9.08	7.75	7.67
12	10.21	16.42	17.92	19.08	13.87	11.04	8.42	7.71	7.42	9.04	7.71	7.67
13	10.25	16.42	17.92	18.79	13.83	10.87	8.42	7.54	7.33	9.00	7.83	7.67
14	10.25	16.29	17.79	18.50	13.79	10.71	8.58	7.37	7.33	8.88	7.71	7.67
15	10.25	16.04	17.54	18.17	13.29	10.54	8.71	7.54	7.33	8.75	7.67	7.67
16	10.17	15.79	17.29	17.96	13.46	10.38	8.67	7.50	7.29	8.66	7.75	7.67
17	10.17	15.54	17.13	17.50	13.37	10.16	8.67	7.50	7.25	8.58	7.75	7.67
18	10.08	15.33	16.87	17.21	13.21	9.88	8.67	7.42	7.33	8.50	7.83	7.75
19	10.08	15.13	16.87	16.96	13.17	9.75	8.62	7.42	7.54	8.42	7.79	7.83
20	10.46	14.85	17.25	16.58	12.88	9.46	8.54	7.84	7.75	8.33	7.88	7.83
21	12.21	14.70	17.83	16.25	12.71	9.41	8.42	7.58	7.79	8.37	7.83	7.92
22	13.04	14.54	18.83	15.87	12.42	9.29	8.29	8.12	7.75	8.42	7.83	7.92
23	13.54	14.36	19.46	15.58	12.50	9.08	8.12	8.21	7.62	8.33	7.79	7.92
24	14.46	14.20	20.04	15.58	12.38	8.88	8.04	8.29	7.66	8.25	7.88	8.08
25	15.33	14.00	20.62	15.75	12.13	8.83	7.88	8.42	7.88	8.20	7.88	8.08
26	15.91	13.80	21.12	15.92	12.08	8.71	7.79	8.42	8.94	8.20	7.83	8.21
27	16.08	13.60	21.67	15.87	11.96	8.54	7.75	8.42	9.63	8.08	7.83	8.29
28	16.29	13.58	21.83	15.87	11.79	8.38	7.75	8.33	9.44	8.00	7.58	8.71
29	16.33	14.00	21.75	15.54	11.67	8.21	7.62	8.25	9.33	8.00	7.58	8.75
30	16.25	.....	21.62	16.00	11.75	8.13	7.54	8.25	9.54	8.00	7.58	8.83
31	16.04	.....	21.46	.....	11.67	.....	8.84	8.12	.....	7.92	.....	8.75

[a] River frozen over from January 1 to March 20, 1904. Average thickness 0.1 foot to 1 foot.
[b] Ice December 13 to 31.

DESPLAINES RIVER ABOVE JACKSON CREEK, NEAR CHANNAHON, ILL.

This station was established October 23, 1902, by E. H. Heilbron. It is located just above the mouth of Jackson Creek, 2½ miles southwest of Millsdale, Ill. The gage is a vertical staff graduated to feet and tenths, and is read daily by Ruth Alexander. The measurements are taken from a cable and boat. The initial point for sounding is a red hub driven in the ground on the left bank near the end of the cable. The channel is straight for about 3,000 feet both above and below the station and has a width of 360 feet and a maximum depth of 16 feet at ordinary stages. Its flow is moderately rapid. Both banks of the stream are low and liable to overflow, but a few feet from the top of the banks on either side are high ridges, which never overflow. Measurements can be made at all stages. The bed of the stream is gravel.

The bench mark is the top of a red oak hub (the initial point for sounding) driven in the bluff between Jackson Creek and the south bank of Desplaines River. It is about 300 feet west of the west line of sec. 15, T. 37 N., R. 9 E., third principal meridian, and is on the farm owned by George Alexander. Elevation, 64.262 feet below the Chicago datum. The gage is set with its zero at the same elevation as the zero of the Chicago datum, thus giving directly the elevation of the river surface below this datum. This station was located to give the discharge of upper Desplaines River.

The excessively large discharge at this station is due to the fact that between 4,000 and 5,000 second-feet are constantly being diverted from Lake Michigan into Desplaines River a short distance above this gaging station.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Desplaines River above the mouth of Jackson Creek, near Channahon, Ill., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
January 21[a]	E. H. Heilbron	375	5,133	1.70	78.00	8,535
January 22[a]	do	440	6,468	1.09	75.20	7,062
March 24	do	440	6,240	2.62	76.06	16,330
March 24	do	437	6,324	2.57	76.10	16,230
March 24	do	430	6,057	2.56	76.32	15,530
March 25	do	465	6,654	2.61	74.80	17,340
March 25	do	477	6,813	2.63	74.60	17,940
March 25	do	485	7,112	2.82	74.10	20,080
March 27	do	450	6,386	2.48	75.64	15,820
April 3	do	384	5,071	2.09	78.80	10,610
April 14	do	360	3,936	1.40	81.80	5,548

[a] Partly frozen. Ice gorge below Kankakee River.

All gage heights are negative, being below Chicago datum.

Mean daily gage height,[a] in feet, of Des Plaines River above the mouth of Jackson Creek, near Channahon, Ill., for 1904.

Day.	Jan.[b]	Feb.[b]	Mar.[b]	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.[c]
1	81.01	78.47	76.65	77.78	82.59	82.92	83.29	82.98	82.98	83.53	83.85	83.10
2	80.76	78.85	76.96	78.04	82.61	82.88	83.38	83.20	83.02	83.58	83.80	82.97
3	80.60	78.80	75.17	78.91	82.65	82.91	83.22	83.10	83.05	83.60	83.75	83.03
4	80.62	78.97	76.65	79.68	82.77	82.95	83.15	83.11	83.10	83.64	83.01	82.90
5	80.84	78.56	77.96	80.18	82.74	82.90	83.26	83.05	83.03	83.60	83.05	82.84
6	80.79	78.15	78.13	80.45	82.59	82.95	83.30	83.03	83.16	83.62	83.20	82.90
7	80.98	75.55	76.91	80.90	82.65	82.80	83.20	83.02	82.96	83.68	83.01	82.81
8	81.58	75.02	77.96	80.70	82.68	83.00	83.10	83.11	83.02	83.50	83.51	82.75
9	81.20	76.61	78.52	81.16	82.58	83.38	83.11	83.10	83.65	83.62	83.00	82.77
10	80.41	76.89	78.52	81.10	82.60	83.42	83.36	83.05	83.65	83.58	82.98	84.00
11	80.51	77.44	78.46	81.22	82.70	83.48	83.10	83.12	83.62	84.15	83.01	82.97
12	80.60	78.08	78.78	81.32	82.78	83.50	83.10	83.08	83.72	83.55	83.12	82.65
13	81.04	78.53	78.78	81.70	82.86	83.50	83.19	83.04	83.62	83.64	82.82	82.95
14	82.28	78.75	78.74	81.78	82.75	84.02	83.18	83.36	83.22	83.56	83.09	82.84
15	80.63	79.38	78.84	81.85	82.69	83.85	83.15	83.24	83.67	83.00	82.99	82.93
16	80.43	79.50	79.78	82.35	82.70	83.48	83.05	83.08	83.90	83.00	83.06	82.97
17	80.65	79.68	80.70	82.38	82.65	83.80	83.05	83.18	83.70	82.97	82.97	82.96
18	80.70	79.75	80.96	82.44	82.60	83.68	83.16	83.31	82.87	83.60	83.15	83.05
19	80.82	79.78	79.42	82.35	82.69	83.70	83.22	83.04	82.95	83.60	83.05	82.94
20	80.50	79.90	78.47	82.56	82.76	83.78	83.18	83.72	83.68	83.82	82.99	82.96
21	78.16	79.85	78.55	82.58	82.87	83.75	83.11	83.92	83.71	83.88	83.16	83.02
22	75.06	79.95	76.31	82.62	82.97	83.65	83.00	83.05	83.86	83.53	83.08	83.00
23	75.30	79.95	75.27	82.68	83.25	83.82	83.07	83.10	83.80	83.87	83.17	82.85
24	75.54	79.95	76.15	81.44	83.15	84.00	83.14	82.91	83.80	83.77	83.01	82.77
25	75.52	80.20	74.37	81.38	82.95	83.90	83.02	82.88	83.70	83.89	83.00	82.85
26	75.86	80.20	74.80	81.05	82.95	83.82	83.05	82.90	83.60	83.88	83.09	83.07
27	76.74	80.17	75.95	81.40	83.00	83.89	82.95	82.95	83.68	83.87	84.40	83.00
28	77.37	80.15	76.92	81.79	82.98	83.57	83.00	83.00	83.01	83.83	84.25	83.13
29	77.74	78.46	77.85	82.13	83.00	83.58	83.00	82.92	83.02	84.50	84.10	82.98
30	77.92	.....	78.86	82.41	82.72	83.20	83.00	82.90	83.48	83.87	83.95	82.70
31	78.20	.....	78.60	.....	82.90	.....	82.98	83.00	.....	83.83	.....	82.67

[a] All gage heights of this station are negative (−), being below Chicago datum.
[b] Ice conditions January 1 to about March 15.
[c] Frozen December 11 to 31.

Rating table for Des Plaines River above the mouth of Jackson Creek, near Channahon, Ill., from March 14, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
84.0	4,480	82.8	5,580	81.2	7,580	78.5	11,620
83.9	4,545	82.7	5,700	81.0	7,840	78.0	12,470
83.8	4,615	82.6	5,820	80.8	8,100	77.5	13,320
83.7	4,690	82.5	5,940	80.6	8,370	77.0	14,170
83.6	4,770	82.4	6,060	80.4	8,650	76.5	15,070
83.5	4,855	82.3	6,180	80.2	8,930	76.0	15,970
83.4	4,945	82.2	6,300	80.0	9,210	75.5	16,870
83.3	5,040	82.1	6,420	79.8	9,510	75.0	17,770
83.2	5,140	82.0	6,545	79.6	9,830	74.0	19,570
83.1	5,245	81.8	6,800	79.4	10,150	73.0	21,370
83.0	5,355	81.6	7,060	79.2	10,470		
82.9	5,465	81.4	7,320	79.0	10,790		

The above table is applicable only for open-channel conditions. It is based upon 21 discharge measurements made during 1903 and 1904, inclusive. It is not well defined. All gage heights are negative, being below Chicago datum. Above gage height —77.0 feet the rating curve is a tangent, the difference being 180 per tenth.

Estimated monthly discharge of Des Plaines River above the mouth of Jackson Creek, near Channahon, Ill., for 1903 and 1904.

[Drainage area, 1,170 square miles.]

Month.	1903.			1904.		
	Discharge in second feet.			Discharge in second-feet.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
March 16 to 31	9,990	6,180	7,559	19,030	7,892	13,180
April	10,790	5,090	6,844	12,840	5,724	7,565
May	5,557	5,030	5,235	5,904	5,090	5,604
June	5,580	5,192	5,420	5,580	4,468	4,919
July	6,300	5,234	5,460	5,410	4,964	5,215
August	5,820	4,992	5,333	5,488	4,532	5,247
September	8,165	5,182	6,001	5,500	4,545	4,967
October	5,880	5,322	5,554	5,388	4,200	4,740
November	6,420	4,200	5,483	5,557	4,250	5,098
December	8,426	4,754	6,489	6,084	4,480	5,443

Miscellaneous discharge measurements of Illinois River at highway bridge, near Havana, Ill., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Feet per second.*	*Feet.*	*Sec.-ft.*
March 28	E. H. Heilbron	1,034	15,990	4.65	19.40	74,310
March 29	do	1,034	16,260	4.68	19.70	76,070
April 1	do	1,035	16,410	4.90	19.90	80,300
April 16	do	1,035	13,830	3.58	17.20	49,530
April 18	do	726	13,160	4.41	18.95	[a] 58,050
April 25	do	1,034	11,270	3.29	14.90	37,100
May 1	do	1,034	11,270	3.10	14.80	34,950

[a] Channel obstructed by drift.

ALLEGHENY RIVER DRAINAGE BASIN.

Allegheny River, which, with the Monongahela, forms the Ohio at Pittsburg, rises in northern Pennsylvania, flows north into the State of New York, then flows south through western Pennsylvania. The headwaters have an elevation of about 2,500 feet, and join those of Genesee River on the north and of the Susquehanna on the east. The total length from the source to the mouth at Pittsburg is about 300 miles, 47 of which are in the State of New York. The principal facts concerning this river have been given in a report by Mr. George M. Lehman, assistant engineer, contained in House Document No. 72, Fifty-fifth Congress, third session. Although this river drains a large area, much of which is of an elevated and even mountainous character, yet it is of comparatively small value for water power. The total fall in 255 miles between Olean, N. Y., and the mouth is only 725 feet, or an average of less than 3 feet per mile. This descent is accomplished without abrupt pitches and even with few rapids having a fall of much consequence. Between Olean and the mouth of Kiskiminitas River, 30 miles above Pittsburg, the greatest amount of natural fall on any ripple less than a thousand feet long is 3.9 in 850 feet at Pattersons Falls. During about half of the year the river is navigable for small steamers to Franklin, 123 miles above Pittsburg.

The drainage areas of the river and its chief tributaries are given in the following table:

River.	Locality.	Drainage area.
		Sq. miles.
Allegheny	Mouth	11,100
Do	Kittanning	8,700
Do	Above mouth of French Creek.	5,950
Do	Franklin	5,670
Do	Warren	3,050
Do	Salamanca	1,560
Do	Olean, below Olean Creek	1,100
Do	Port Allegheny	220
Conewago Creek	Mouth	935
Tionesta Creek	do	458
French Creek	do	1,180
Clarion	do	1,175
Red Bank Creek	do	526
Mahoning Creek	do	397
Kiskiminitas	do	1,846
Do	Salina	1,770
Blacklick Creek	Blacklick	403

During 1904 the United States Geological Survey has maintained gaging stations in this basin at the following places: Allegheny River at Redhouse, N. Y.; Kittanning, Pa.; Chadakoin River at Jamestown, N. Y.; Kiskiminitas River at Salina, Pa.; Blacklick Creek at Blacklick, Pa.

ALLEGHENY RIVER AT REDHOUSE, N. Y.

This station was established September 4, 1903, by R. E. Horton, assisted by C. C. Covert. It is located at the Redhouse Bridge near the stations of the Erie and Pennsylvania railroads and about 5 miles below Salamanca, N. Y., and about 13 miles above the point where the river leaves New York State. The standard chain gage is fastened to the upstream side of the bridge near the middle of the left span. The length of the chain from the end of the weight to the marker is 24.16 feet. The gage is read twice each day by James H. Smith. Discharge measurements are made from the downstream side of the bridge. The initial point for soundings is the left end of the downstream side of the bridge. The channel is straight for 800 feet above and below the bridge. The current velocity is well distributed. The right bank is high and does not overflow. The left bank overflows only at flood stages. The bed of the stream is of gravel, and is regular.

The channel is 494 feet wide between abutments, broken by two piers. At extreme high water there is an additional flood channel on the left bank. The bench mark is a circle cut on the downstream side of the left abutment. Its elevation is 21.09 feet above the water surface when the gage reads zero.

The observations at this station during 1904 have been made under the direction of R. E. Horton, district hydrographer.

Discharge measurements of Allegheny River at Redhouse, N. Y., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Sq. feet.	*Ft. per sec.*	*Feet.*	*Second-ft.*
April 10	Horton and Mott	2,807	4.97	8.35	14,220
July 18	C. C. Covert	1,198	.99	3.68	1,188

Mean daily gage height, in feet, of Allegheny River at Redhouse, N. Y., for 1904.

Day.	Jan.[a]	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.[b]	Dec.[b]
1	.....	4.70	6.10	7.30	6.30	7.32	3.25	3.32	3.45	4.50	3.90	3.9
2	.....	4.50	6.85	8.35	5.90	6.55	3.55	3.28	3.38	4.18	3.85	3.8
3	.....	4.35	8.50	7.85	5.55	6.05	3.55	3.20	3.45	4.05	3.80	3.8
4	.....	4.00	8.68	7.28	5.25	5.56	3.40	3.20	3.70	4.00	3.72	3.8
5	.....	4.30	8.00	6.88	4.98	5.32	3.48	3.20	3.45	3.88	3.62	3.8
6	4.50	4.40	7.28	6.55	4.82	5.05	3.82	3.20	3.40	3.78	3.50	3.8
7	4.50	8.60	8.75	6.25	4.60	4.85	3.90	3.20	3.32	3.70	3.50	3.7
8	4.50	10.70	10.50	6.12	4.48	4.60	3.75	3.12	3.30	3.70	3.50	3.8
9	4.50	9.85	10.10	7.80	4.40	4.60	3.60	3.10	3.22	3.80	3.50	3.8
10	4.50	9.00	9.05	8.32	4.25	4.42	6.05	3.00	3.20	4.00	3.50	3.8
11	4.50	8.10	7.82	7.78	4.20	4.25	6.00	3.00	3.20	4.70	3.45	3.8
12	4.50	7.00	6.75	7.50	4.12	4.00	5.20	3.00	3.20	5.00	3.40	3.8
13	4.50	6.00	6.12	7.10	4.05	3.95	5.45	3.00	3.12	5.10	3.50	3.8
14	4.50	5.48	5.50	6.50	3.90	3.80	4.95	3.00	3.10	5.00	3.50	3.8
15	.....	4.90	5.12	6.00	4.05	3.80	4.40	3.00	3.10	4.70	3.45	3.8
16	4.50	4.55	4.85	5.50	4.22	3.75	4.15	3.00	3.10	4.45	3.45	3.8
17	.....	4.40	4.60	5.70	4.15	3.55	3.95	3.00	3.20	4.25	3.40	3.8
18	4.50	4.30	4.68	5.80	4.20	3.50	3.80	3.00	3.25	4.10	3.35	3.8
19	4.50	4.10	4.70	5.65	6.15	3.50	3.70	3.00	3.22	3.95	3.30	3.8
20	4.50	3.95	5.45	5.35	6.20	3.48	3.50	3.15	3.12	3.78	3.30	3.8
21	4.60	.....	5.88	5.20	5.72	3.52	3.48	3.60	3.05	3.68	3.30	3.8
22	7.00	.....	5.55	5.20	5.35	3.62	3.38	4.00	3.00	4.15	3.30	3.8
23	9.95	.....	8.25	5.00	5.15	3.80	3.30	4.35	3.00	5.10	3.30	3.8
24	9.40	4.58	8.85	4.82	5.80	3.65	3.58	4.40	3.05	5.10	3.30	3.8
25	8.95	4.38	8.98	5.22	5.90	3.48	3.45	4.15	4.20	4.90	3.30	3.8
26	8.10	4.00	11.10	5.35	5.65	3.40	3.32	3.90	4.75	4.60	3.25	3.8
27	6.90	3.95	10.70	5.20	6.60	3.28	3.30	3.90	4.70	4.60	3.40	3.8
28	6.45	3.85	9.50	5.80	6.45	3.20	3.30	4.00	4.45	4.50	3.30	3.8
29	6.10	4.10	8.20	6.30	5.78	3.20	3.68	3.70	4.15	4.30	3.20	3.8
30	5.40	.....	7.25	6.70	5.65	3.20	3.65	3.52	4.50	4.20	3.25	3.8
31	5.00	.....	6.88	.....	7.50	.....	3.45	3.45	.....	4.00	.....	3.8

[a] River frozen January 1 to 23. Ice about 1 foot thick.
[b] River frozen November 28 to December 26.

ALLEGHENY RIVER AT KITTANNING, PA.

This station, which is located at Market Street Bridge, was established August 18, 1904, by R. J. Taylor. A standard chain gage is bolted to the outside of the upstream hand rail in the first span from the left bank. The length of the chain from the end of the weight to the marker is 38.67 feet. Discharge measurements are made from the downstream foot walk of the five-span steel highway bridge to which the gage is attached. The initial point for soundings is the left end of the hand rail on the downstream side of the bridge. The channel, which is broken by four piers at the station, is straight for about 500 feet above and for 1,000 feet below. The current is swift. Both banks are high, clean, and do not overflow. The bed of the stream is composed of clean gravel, and is permanent. The water is approximately 3 to 4 feet deep in the first three channels and 6 to 8 feet deep in the last two at low stages. The gage is read twice daily by S. B. Cochrane.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Allegheny River at Kittanning, Pa., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
August 18	R. J. Taylor	620	2,615	0.82	2.40	2,140
September 19	E. C. Murphy	603	2,602	.79	2.26	2,046
September 29	N. C. Grover	720	4,010	1.77	4.42	7,087

Mean daily gage height, in feet, of Allegheny River at Kittanning, Pa., for 1904.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.[b]	Day.	Aug.	Sept.	Oct.	Nov.	Dec.[b]
1	.....	2.90	3.80	3.80	2.30	17	.....	2.20	4.00	(a)	2.90
2	.....	2.80	4.00	3.60	2.60	18	.....	2.40	3.70	(a)	3.00
3	.....	2.80	4.00	3.40	2.70	19	.....	2.20	3.50	(a)	3.30
4	.....	2.70	3.80	3.30	2.80	20	.....	2.20	3.30	2.50	3.20
5	.....	2.80	3.80	3.10	2.70	21	.....	2.10	3.20	2.40	3.00
6	.....	3.50	3.40	3.10	2.50	22	.....	2.00	3.30	2.40	2.90
7	.....	3.30	3.40	3.20	2.50	23	.....	2.00	3.30	2.40	2.90
8	.....	3.00	3.10	3.00	2.60	24	.....	2.00	4.30	2.30	3.40
9	.....	2.70	3.00	2.80	2.50	25	.....	4.50	2.00	5.70	2.40	8.30
10	.....	2.70	2.80	2.80	2.30	26	.....	3.90	2.00	6.00	2.40	7.30
11	.....	2.80	2.60	2.80	2.70	27	.....	3.90	3.40	5.70	2.40	8.00
12	.....	2.70	3.40	2.80	2.80	28	.....	4.10	4.60	5.10	2.30	11.90
13	.....	2.60	3.60	2.80	2.80	29	.....	3.70	4.50	4.70	2.30	12.40
14	.....	2.40	4.30	2.70	2.90	30	.....	3.40	4.10	4.40	2.30	10.60
15	.....	2.30	4.40	(a)	2.90	31	.....	3.10	.....	4.10	.....	8.80
16	.....	2.20	4.10	(a)	2.90							

[a] Gage out of order. River stationary from November 15 to 19, inclusive.
[b] Reading taken to top of ice, December 12 to 31.

CHADAKOIN RIVER AT JAMESTOWN, N. Y.

Chadakoin River drains Lake Chautauqua, entering Allegheny River in Pennsylvania, through Conewango Creek. Lake Chautauqua extends in a northwest and southeasterly direction, having its head at a distance of 8 miles from Lake Erie, its water surface being at elevation 1,308 feet above sea level or 735 feet above Lake Erie. The drainage area above the foot of the lake is 190.6 square miles, of which 20.8 square miles comprises the lake surface, which represents 10.9 per cent of the drainage area. The land tributary to the lake is very rolling and the soil is impervious. Chadakoin River furnishes water power at numerous dams.

A gaging station was established on Chadakoin River April 3, 1904, by R. E. Horton. It is located at the outlet of Lake Chautauqua, near Jamestown, N. Y. The gage is read once each day by R. L. Carlson.

The observations at this station during 1904 have been made under the direction of R. E. Horton, district hydrographer.

Discharge measurements of Chadakoin River at Jamestown, N. Y., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Sq. feet.	*Ft. per sec.*	*Feet.*	*Second-ft.*
April 11	Horton and Mott	385	2.88	2.38	1,110
July 19	C. C. Covert	290	1.70	1.90	494

Daily gage height, in feet, of Chadakoin River at Jamestown, N. Y., for 1904.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.20	2.40	1.90	1.90	1.50	1.20	2.00	1.70
2	.....	2.30	2.50	2.00	1.80	1.40	1.50	2.00	1.70
3	3.00	2.30	2.80	1.90	1.70	1.50	.80	2.00	1.80
4	2.95	2.20	2.40	2.00	1.60	1.50	.70	2.00	1.70
5	3.00	2.30	2.60	1.90	2.20	1.50	.80	1.80	1.70
6	2.95	2.20	2.60	2.00	2.00	1.40	.80	2.00	1.90
7	2.85	2.10	2.40	2.00	2.00	1.10	.80	1.60	1.60
8	2.85	2.10	2.40	2.00	2.10	1.10	.80	1.80	1.60
9	2.80	2.00	2.30	1.80	1.80	1.10	1.30	2.00	1.60
10	2.80	2.10	2.20	2.20	1.80	1.20	1.40	1.80	1.50
11	2.80	2.10	2.30	2.40	1.80	1.10	1.40	1.80	1.80
12	2.70	2.00	2.10	2.30	1.70	1.10	1.50	1.80	1.80
13	2.80	1.90	2.00	2.30	1.80	.90	1.50	1.90	1.50
14	2.65	1.90	2.10	2.30	2.10	1.10	1.60	1.90	1.50
15	2.60	1.80	1.90	2.20	1.70	1.20	1.40	1.80	1.40
16	2.70	2.10	2.10	2.20	1.70	1.50	1.20	1.80	1.40
17	2.60	1.90	2.00	2.10	1.90	1.30	1.20	1.80	1.50
18	2.50	2.00	2.10	2.20	1.70	1.20	1.20	1.70	1.50
19	2.70	2.10	2.10	1.90	1.40	1.20	1.20	1.70	1.50
20	2.50	2.20	2.00	1.80	1.90	1.10	1.20	1.80	1.50
21	2.40	2.20	2.20	2.20	1.80	.90	.....	1.90	1.50
22	2.40	2.08	2.30	1.80	1.90	.80	.....	1.90	1.40
23	2.30	2.10	2.20	2.20	1.80	.80	.....	2.00	1.50
24	2.20	2.30	2.00	1.80	1.80	.80	.....	2.00	1.50
25	2.30	2.20	2.10	2.00	1.80	1.50	.....	2.00	1.60
26	2.80	2.30	2.00	2.00	1.70	1.40	1.90	2.00	2.00
27	2.30	2.50	2.10	2.10	1.50	1.30	1.90	2.00	1.80
28	2.30	2.40	1.80	2.10	1.90	1.40	1.90	1.80	1.90
29	2.40	2.20	2.00	2.10	1.70	1.30	1.60	1.80	1.90
30	2.30	2.10	1.80	1.80	1.60	1.40	2.00	1.70	2.10
31	.....	2.20	.....	2.00	1.50	.....	2.00	.....	2.00

KISKIMINITAS RIVER AT SALINA, PA.

This station was established August 17, 1904, by R. J. Taylor. It is located at the highway bridge between the village at Salina, Pa., and the Pennsylvania Railroad station, and about 200 feet from the latter. A standard chain gage is bolted to the outside of the hand rail on the downstream side of the bridge. The length of the chain from the end of the weight to the marker is 36.76 feet. Bench mark No. 1 is a chisel draft on a shelf on the downstream corner of the right abutment. Its elevation is 5.77 feet above the datum of the gage. Bench mark No. 2 is a chisel draft on the top of the downstream corner of the right abutment. Its elevation is 30.39 feet above the datum of the gage. Discharge measurements are made from the downstream side of the two-span steel bridge to which the gage is attached. The initial point for soundings is the right end of the guard rail on the downstream side of the bridge. The channel is

straight for about 300 feet above and for 500 feet below the station. The current is swift. Both banks are high, rocky, clean, and are not subject to overflow. The bed of the stream is composed of rock and is clean and permanent. At low stages all the water passes beneath the right span of the bridge. Water will begin to flow beneath the left span when the gage reads about 1.50 to 1.70 feet. At such times the water in the left channel is too shallow to measure, but the velocity may be estimated very closely. The gage is read once each day by J. F. Whitesell.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Kiskiminitas River at Salina, Pa., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft*
August 17	R. J. Taylor	153	222	2.48	1.50	550
September 20	E. C. Murphy	144	161	1.74	1.22	281
September 30	N. C. Grover	140	132	1.32	1.07	174

Mean daily gage height, in feet, of Kiskiminitas River at Salina, Pa., for 1904.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	1.15	1.00	1.10	0.90	17	.....	1.40	1.40	1.10	1.00
2	.....	1.15	.90	1.10	.90	18	1.70	1.40	1.22	1.12	1.00
3	.....	1.35	.90	1.05	.90	19	1.65	1.40	1.20	1.10	1.00
4	.....	1.30	.85	1.05	.88	20	1.80	1.30	1.15	1.10	1.00
5	.....	1.20	.80	1.05	.85	21	1.70	1.15	1.10	1.10	1.00
6	.....	1.25	1.00	1.02	1.00	22	1.80	1.15	1.10	1.10	1.00
7	.....	1.15	1.20	1.02	1.10	23	1.78	1.10	1.20	1.05	1.00
8	.....	1.20	1.20	1.00	1.10	24	1.70	1.00	1.55	1.05	[b]1.70
9	.....	1.25	1.20	1.10	1.10	25	1.62	1.02	1.45	1.02	[c]5.00
10	.....	1.60	1.20	1.10	1.12	26	1.60	1.02	1.45	1.02	4.40
11	.....	1.60	1.50	1.10	[a]1.00	27	1.52	1.00	1.30	1.02	5.30
12	.....	1.65	1.52	1.12	1.00	28	1.50	1.00	1.20	1.02	6.70
13	.....	1.50	1.60	1.15	1.00	29	1.38	1.00	1.20	1.00	5.25
14	.....	1.30	1.60	1.20	1.00	30	1.25	1.00	1.15	1.00	[d]8.35
15	.....	1.35	1.50	1.15	1.00	31	1.20	.....	1.15	.....	[d]8.30
16	.....	1.40	1.45	1.10	1.00						

[a] River frozen from December 11 to 24, inclusive.
[b] December 24 water running over ice.
[c] Ice gone.
[d] Ice gorge.

BLACKLICK CREEK AT BLACKLICK, PA.

This station was established August 16, 1904, by R. J. Taylor. It is located at the covered wooden highway bridge one-fourth mile from the railway station at Blacklick. A standard chain gage is spiked to the floor on the upstream side of the first span near the left bank.

The length of the chain from the end of the weight to the marker is 17.32 feet. The bench mark is a chisel draft on top of upstream corner of left-hand abutment; elevation 15.63 feet above the datum of the gage. During low water discharge measurements are made by wading just below the bridge. At high water discharge measurements are made from a coal-mine tipple crossing the stream one-fourth mile above the bridge to which the gage is attached. The channel is divided at this point by piers into three channels at both low and high water. The gage is read once each day by Mark Maynard.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Blacklick Creek at Blacklick, Pa., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
August 12	R. J. Taylor	205	242	0.26	2.02	63
September 20	E. C. Murphy	130	61	.74	1.94	45
September 30	N. C. Grover	100	37	.62	1.84	23

Mean daily gage height, in feet, of Blacklick Creek at Blacklick, Pa., for 1904.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	1.88	1.95	2.00	2.05	17	2.18	2.15	2.22	2.15	(a)
2	.....	1.90	1.92	2.00	2.30	18	2.15	2.00	2.20	2.15	(a)
3	.....	1.92	1.85	1.98	2.25	19	2.12	2.00	2.10	2.12	(a)
4	.....	1.90	1.85	1.95	2.25	20	2.02	1.95	2.00	2.00	(a)
5	.....	1.90	1.90	1.90	2.30	21	2.20	1.90	2.25	2.00	(a)
6	.....	1.90	2.10	1.90	2.30	22	2.32	1.90	2.65	1.98	(a)
7	.....	1.90	2.15	2.00	(a)	23	2.42	1.95	2.55	1.95	(a)
8	.....	1.90	2.10	2.10	(a)	24	2.35	1.95	2.45	1.90	(b)
9	.....	2.00	2.00	2.15	(a)	25	2.25	2.00	2.30	2.00	4.20
10	.....	2.10	2.00	2.20	(a)	26	2.50	2.02	2.20	2.00	3.90
11	.....	2.25	2.35	2.25	(a)	27	2.25	2.05	2.20	2.00	6.90
12	.....	2.10	2.62	2.30	(a)	28	2.08	2.02	2.15	2.00	5.30
13	.....	2.02	2.50	2.25	(a)	29	1.98	2.00	2.10	2.00	4.30
14	.....	2.00	2.45	2.20	(a)	30	1.95	2.00	2.10	2.05	3.80
15	.....	2.20	2.30	2.20	(a)	31	1.90	.....	2.00	.....	3.70
16	.....	2.25	2.30	2.15	(a)						

(a) Ice. (b) Ice went out.

MONONGAHELA RIVER DRAINAGE BASIN.

Monongahela River is formed near Fairmont in Marion County, in the northern part of West Virginia, by the union of its West Fork with Tygarts Valley River. The headwaters of the latter stream lie on the slopes and in the valleys of the Appalachian Mountains near

the eastern boundary of West Virginia; thence they flow northward, draining a hilly and mountainous country. The West Fork has its headwaters west of those of Tygarts Valley River in the central part of West Virginia; thence they flow northerly, draining a hilly country.

The principal tributaries of Monongahela River below Fairmont are Cheat and Youghiogheny rivers, both entering from the east. Cheat River drains a rugged, mountainous district in northern West Virginia, and flows into Monongahela River near Point Marion, Pa. Youghiogheny River drains a mountainous district of Maryland and Pennsylvania, and enters the Monongahela about 15 miles above Pittsburg. The basins of all of these tributary rivers have steep slopes and collect and discharge their waters quickly, with the result that the Monongahela is liable to the excessive freshets for which it is noted. The whole basin was once heavily timbered, but has been quite thoroughly cleared except about the upper waters of the principal streams. Little water power is used in the basin. Navigation extends to Fairmont.

CHEAT RIVER NEAR MORGANTOWN, W. VA.

A cable station was established July 8, 1899, by E. G. Paul, at Uneva, about 7 miles from Morgantown, W. Va. On July 26, 1901, the cable was moved about 1 mile downstream, in order to secure a more satisfactory cross section and better facilities for observing gage heights. An inclined timber gage was established at the present station August 21, 1902. It is located 275 feet below the cable and is inclined up to 6.5 feet, above which point readings are taken on a vertical timber spiked to an ash tree. On September 28, 1904, a standard chain gage was installed by N. C. Grover on the new steel bridge, known as Ice's ferry bridge, and near the site of the first cable, and both gages have been read during the remainder of the year. They were set to read the same, and their records have checked very closely. The published record is that for the inclined gage. The channel is straight for about 800 feet above and 1,200 feet below the station. The right bank is low and liable to overflow; the left bank is high. The bed of the stream is of rocks and gravel and the current is sluggish. The bench mark is a mark on the face of a sandstone rock at the edge of the road, 20 feet downstream and 30 feet back from the gage. Its elevation above gage datum is 21.13 feet.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Cheat River near Morgantown, W. Va., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Feet per sec.*	*Feet.*	*Sec.-feet.*
July 6.....	J. C. Hoyt and W. E. Hall.	300	1,226	0.63	2.60	773
September 16 ..	R. J. Taylor	275	887	.15	2.00	136

Mean daily gage height, in feet, of Cheat River near Morgantown, W. Va., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1.....	3.30	3.60	6.40	6.40	6.25	3.40	3.60	2.15	1.80	1.60	2.00	2.00
2.....	3.25	3.00	6.80	6.50	5.85	3.45	4.00	2.25	1.85	1.85	2.00	2.05
3.....	[a]8.50	3.25	7.20	5.95	4.95	3.50	3.65	2.15	1.85	1.90	1.90	2.20
4.....	11.00	3.15	8.30	5.10	5.00	3.90	3.35	2.35	1.85	1.90	1.90	2.10
5.....	11.00	3.00	6.40	4.55	4.55	3.85	3.00	2.55	1.85	1.90	1.90	2.10
6.....	11.00	3.00	5.50	4.30	4.20	4.80	3.00	2.35	1.80	1.85	1.90	2.60
7.....	11.00	4.90	6.10	4.15	3.95	4.30	3.65	2.25	1.75	1.85	1.82	2.50
8.....	11.00	8.60	7.40	4.05	3.75	4.10	3.50	2.30	1.75	1.90	1.80	2.50
9.....	11.00	6.30	6.60	4.05	3.55	3.85	3.40	2.15	1.75	1.80	1.80	2.50
10.....	11.00	5.35	5.70	4.15	3.75	3.70	3.30	2.05	1.75	1.90	1.80	2.40
11.....	11.00	4.65	5.15	4.00	3.75	3.50	3.55	2.05	1.75	1.95	1.80	2.35
12..	11.00	4.00	5.05	3.85	3.45	3.30	3.50	2.00	1.75	2.00	1.80	2.20
13.....	11.00	3.60	4.90	3.80	3.30	3.10	3.35	2.05	1.75	2.05	1.80	2.15
14.....	11.00	3.65	4.55	3.85	3.25	2.90	3.05	2.05	1.85	2.75	1.80	2.05
15.....	11.00	3.80	5.15	3.70	3.40	2.85	2.80	2.05	1.85	2.30	1.90	2.15
16.....	11.00	3.40	4.95	3.95	3.70	2.85	2.70	1.95	2.10	2.20	1.95	2.15
17.....	11.00	2.95	4.40	5.05	3.65	2.75	2.55	1.95	1.95	2.15	1.88	2.10
18.....	11.00	3.15	4.35	4.65	3.70	2.90	2.55	1.95	2.00	2.05	1.90	2.20
19.....	11.00	3.00	4.45	4.25	7.20	2.95	2.35	2.00	1.90	2.00	1.90	2.20
20.....	11.00	3.15	4.45	4.00	6.50	2.70	2.30	1.95	1.85	2.00	1.90	2.20
21.....	11.00	3.65	5.10	3.80	6.70	3.25	2.75	2.35	2.20	1.90	2.05	2.15
22.....	[a]21.00	5.70	5.65	3.60	6.30	4.30	3.00	2.10	2.10	2.00	2.10	2.10
23.....	[b]10.80	5.45	8.20	3.45	6.20	4.75	3.25	2.40	1.90	2.00	2.35	2.00
24.....	7.50	6.05	7.80	3.35	4.90	3.45	2.80	2.55	1.85	2.10	2.45	2.60
25.....	5.95	5.40	6.30	3.55	4.45	3.30	2.60	2.55	1.80	2.10	2.40	8.20
26.....	5.05	4.65	5.85	4.70	4.10	2.95	2.45	2.40	1.75	2.00	2.40	7.20
27.....	4.40	4.20	6.00	6.60	4.05	2.85	2.55	2.20	1.75	2.00	2.35	7.20
28.....	3.80	3.95	5.30	7.40	4.15	2.85	2.45	2.05	1.70	2.10	2.05	6.80
29.....	3.75	5.15	4.65	6.30	3.90	3.05	2.50	1.95	1.60	2.00	2.10	5.40
30.....	3.65	.....	4.30	6.05	3.70	3.80	2.35	1.85	1.60	2.00	2.00	4.20
31.....	3.60	.....	4.35	.....	3.55	.....	2.20	1.85	.....	2.00	.....	3.85

[a] Ice gorge January 3 to 22.

[b] Ice passed out January 23.

YOUGHIOGHENY RIVER AT FRIENDSVILLE, MD.

Youghiogheny River rises in Garrett County, Md., flows in a northwesterly direction into Pennsylvania, and is tributary to Monongahela River 15 miles above Pittsburg. Its source is on the western slope of the Allegheny Mountains, at an elevation of about 2,900 feet. The average fall of the stream for 19 miles above its mouth is about 2 feet per mile, but above this point it soon increases to an average fall of nearly 5 feet per mile. The river is liable to excessive freshets and the height of floods above low water ranges between 15 and 30 feet. The following heights of the high water of February, 1897, above low-water stage, at various points in Pennsylvania, were furnished by George M. Lehman: Whikett, 13 feet; Jacobs Creek, 10 feet; Smithton, 14 feet; Port Royal, 17 feet; Snyder, 16 feet; West Newton, 20 feet; Suterville, 22 feet; Buena Vista, 26.5 feet; Coulterville, 28.5 feet; Boston, 29 feet; McKeesport, 28.5 feet.

A measurement of the flow of Youghiogheny River was made October 13, 1892, with surface floats, at Ohiopyle, Pa., by Kenneth Allen, in connection with an investigation of a water supply for the works of the H. C. Frick Coke Company. It was during a period of extreme drought, and the discharge was found to be 106 second-feet.

The station at Friendsville, Md., was established by E. G. Paul on August 17, 1898. The standard chain gage is located on the upstream side of the right span of the bridge and is nailed to the guard rail. The length of the chain from the end of the weight to the marker is 20 feet. A United States Geological Survey bench mark consisting of an aluminum tablet disk marked "1501," is set in the foundation corner stone of the southeast corner of Friend's store; elevation 33.17 feet above the datum of the gage. The initial point for soundings is a point 15 feet back from the face of the right abutment on the upstream side of the bridge. Measurements are made from the iron highway bridge connecting the east and the west portions of the village. The channel is straight for several hundred feet above and below the bridge. The bed is rocky and the banks are high and not subject to overflow. The gage is read twice daily by J. H. Cuppet. This station was discontinued December 31, 1904.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurement of Youghioghney River at Friendsville, Md., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
July 7.....	J. C. Hoyt and W. E. Hall.	145	344	0.46	4.30	157

Mean daily gage height, in feet, of Youghiogheny River at Friendsville, Md., for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.[a]
1	4.30	5.40	8.00	5.70	5.40	4.90	4.60	4.00	3.90	3.80	3.80	3.90
2	4.30	5.10	7.60	5.60	5.30	4.90	4.50	4.00	3.80	3.80	3.80	3.90
3	4.30	5.00	6.80	5.50	5.30	4.90	4.50	4.00	3.80	3.80	3.80	3.90
4	4.30	4.80	6.40	5.50	5.30	4.90	4.40	4.00	3.80	3.80	3.80	3.90
5	4.30	4.60	6.10	5.30	5.20	4.80	4.50	4.10	3.80	3.80	3.80	3.90
6	4.30	4.50	6.00	5.10	5.10	4.80	4.40	4.00	3.80	3.80	3.80	3.90
7	4.30	6.30	5.90	5.10	4.90	4.70	4.30	3.90	3.80	3.90	3.80	3.90
8	4.30	6.00	6.30	5.20	4.80	4.90	4.40	3.90	3.80	3.90	3.80	3.90
9	4.30	6.50	6.60	5.10	4.80	4.80	4.50	3.90	3.90	3.90	3.80	3.90
10	4.30	6.30	6.40	5.00	4.70	4.70	4.50	3.90	3.80	3.90	3.80	3.90
11	4.30	6.20	6.20	5.00	4.60	4.60	4.60	3.80	3.80	3.90	3.80	3.90
12	4.30	5.90	5.90	4.90	4.60	4.50	4.50	3.80	3.80	3.90	3.80	3.90
13	4.30	5.90	5.70	4.80	4.60	4.40	4.50	3.80	3.80	3.90	3.80	3.90
14	4.30	5.90	5.40	4.80	4.50	4.40	4.40	3.80	3.80	3.90	3.80	3.90
15	4.30	5.90	5.20	4.70	4.50	4.30	4.30	3.70	3.80	3.90	3.80	3.90
16	4.30	5.90	5.00	4.80	4.40	4.30	4.20	3.70	3.80	3.90	3.80	3.90
17	5.40	5.90	4.90	4.80	4.50	4.30	4.10	3.70	3.80	3.90	3.80	3.90
18	5.90	5.90	4.80	4.80	5.30	4.30	4.20	3.70	3.80	3.90	3.80	3.90
19	6.30	5.90	5.00	4.80	6.70	4.30	4.00	3.70	3.80	3.90	3.80	3.90
20	7.50	5.90	5.20	4.70	6.80	4.40	4.00	3.70	3.80	3.90	3.80	3.90
21	8.20	5.90	5.30	4.70	6.70	4.50	4.00	3.80	3.80	3.90	3.80	4.60
22	8.60	6.40	5.60	4.70	6.50	4.50	4.00	3.80	3.80	3.90	3.90	4.80
23	9.40	6.20	5.80	4.80	6.10	4.70	4.10	3.80	3.80	3.90	3.90	5.90
24	6.70	6.00	5.60	4.80	5.80	4.80	4.10	3.90	3.80	3.90	3.90	7.80
25	6.00	6.30	5.70	4.80	5.50	4.70	4.20	3.90	3.80	3.90	3.90	8.60
26	5.70	6.80	5.90	5.20	5.20	4.60	4.10	3.90	3.80	3.90	3.80	8.30
27	5.50	7.40	6.00	5.60	5.20	4.50	4.10	3.80	3.80	3.90	3.80	7.50
28	5.60	7.60	6.30	5.80	5.00	4.50	4.00	3.80	3.80	3.90	3.90	6.70
29	5.80	8.20	6.20	5.60	5.00	4.60	4.00	3.80	3.80	3.90	3.90	5.90
30	5.70	.....	6.10	5.40	5.00	4.70	4.00	3.80	3.80	3.90	3.90	5.40
31	5.50	.....	5.90	.....	5.00	.....	4.10	3.80	.....	3.90	.....	5.10

[a] Frozen during portions of January, February, and December.

Rating table for Youghiogheny River at Friendsville, Md., from January 1, 1902, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.6	12	4.4	230	5.6	1,150	6.8	2,512
3.65	18	4.5	280	5.7	1,260	6.9	2,626
3.7	25	4.6	340	5.8	1,372	7.0	2,740
3.75	35	4.7	400	5.9	1,486	7.2	2,968
3.8	45	4.8	464	6.0	1,600	7.4	3,196
3.85	55	4.9	530	6.1	1,714	7.6	3,424
3.9	65	5.0	600	6.2	1,828	7.8	3,652
3.95	77	5.1	685	6.3	1,942	8.0	3,880
4.0	90	5.2	770	6.4	2,056	8.5	4,450
4.1	120	5.3	862	6.5	2,170	9.0	5,020
4.2	150	5.4	955	6.6	2,284	9.5	5,590
4.3	185	5.5	1,050	6.7	2,398		

The above table is applicable only for open-channel conditions. Curve not well defined.

Estimated monthly discharge of Youghiogheny River at Friendsville, Md., for 1904.

[Drainage area, 295 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January [a]	5,476	185	1,159	3.93	4.53
February [a]	4,108	280	1,667	5.64	6.09
March	3,880	464	1,551	5.26	6.06
April	1,372	400	703	2.38	2.66
May	2,512	230	883	2.99	3.45
June	530	185	351	1.19	1.33
July	340	90	185	.627	.723
August	120	25	55.3	.187	.216
September	45	45	45	.153	.171
October	65	45	61.1	.207	.239
November	65	45	49.7	.168	.187
December [a]	4,564	65	802	2.72	3.14
The year	5,476	25	626	2.12	28.80

[a] January, February, and December approximate on account of ice during portions of the months.

YOUGHIOGHENY RIVER NEAR CONFLUENCE, PA.

This station was established September 15, 1904, by E. C. Murphy. It is located at the highway bridge about one-half mile from the railway station at Confluence, Pa. A standard chain gage is fastened to the downstream hand rail of the bridge. The length of the chain from the end of the weight to the marker is 23.23 feet. Bench mark No. 1 is a cross on the head of a rivet in the bedplate at the right abutment on the downstream side. Its elevation is 20.53 feet above the datum of the gage. Bench mark No. 2 is a cross on the lower chord of the bridge under the gage box. Its elevation is 20.28 feet above gage datum. Discharge measurements are made from the upstream side of the two-span steel bridge to which the gage is attached. The initial point for soundings is the center of the bridge pin over the right abutment on the upstream side of the bridge. The channel is straight for about 200 feet above and for 500 feet below the station. The current is swift. The right bank is high and does not overflow. The left bank is low, clean, and overflows during high water. The bed of the stream is rocky. There are two channels at all stages. There is a small cobble-stone dam about 4 to 6 inches high under the bridge. The gage is read once daily by L. L. Mountain.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Youghiogheny River near Confluence, Pa., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Feet per sec.*	*Feet.*	*Sec.-feet.*
July 7[a]	Hoyt and Hall	235	379	1.40	.....	530
September 12	E. C. Murphy	78	64	.55	1.30	35
September 27	N. C. Grover	190	80	.54	1.37	43

[a] Measured at railroad bridge below junction of Casselman River.

Mean daily gage height, in feet, of Youghiogheny River near Confluence, Pa., for 1904.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1	.....	1.30	1.35	1.40	17	1.35	1.60	1.40	[b] 1.60
2	.....	1.30	1.35	1.40	18	1.35	1.60	1.40	(a)
3	.....	1.30	1.35	1.40	19	1.35	1.50	1.40	(a)
4	.....	1.25	1.35	1.40	20	1.35	1.45	1.40	(a)
5	.....	1.25	1.30	1.40	21	1.40	1.40	1.40	(a)
6	.....	1.25	1.30	1.40	22	1.40	1 40	1.40	(a)
7	.....	1.25	1.30	1.40	23	1.55	1.40	1.40	(a)
8	.....	1.30	1.30	1.40	24	1.55	1.40	1.40	[b] 1.90
9	.....	1.35	1.30	1.40	25	1.50	1.40	1.40	[c] 4.80
10	.....	1.35	1.35	1.40	26	1.40	1.40	1.40	4.25
11	.....	1.40	1.35	(a)	27	1.40	1.40	1.40	4.50
12	.....	1.40	1.35	(a)	28	1.35	1.35	1.40	4.90
13	.....	1.40	1.35	(a)	29	1.35	1.35	1.40	3.80
14	.....	1.70	1.35	(a)	30	1.35	1.35	1.40	3.00
15	.....	1.70	1.35	(a)	31	.....	1.35	.....	2.70
16	1.35	1.65	1.35	(a)					

[a] Frozen. [b] Hole cut in ice and gage read to surface of water. [c] Ice gone out.

CASSELMAN RIVER AT CONFLUENCE, PA.

This station was established September 15, 1904, by E. C. Murphy. It is located at the highway bridge in Confluence, Pa., about 500 yards from the railroad station. A standard chain gage is fastened to the upstream hand rail of the bridge. The length of the chain from the end of the weight to the marker is 21.41 feet. Bench mark No. 1 is a chisel draft marked with paint on the right abutment on the downstream side. Its elevation is 17.88 feet above the datum of the gage. Bench mark No. 2 is a cross on the top of the lower chord of the bridge near the gage. Its elevation is 18.61 feet above the datum of the gage. Discharge measurements are made from the upper side of the two-span steel bridge to which the gage is attached. The initial point for soundings is the center of the bridge pin over the right abutment on the upstream side. The channel is straight for 200 feet above and for 500 feet below the station. The current is swift. The right bank is high, and is not subject to overflow. The left bank

is low and overflows during extreme high water. The bed of the stream is covered with bowlders and there is some vegetation. There are two channels at all stages. The gage is read once each day by L. L. Mountain.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Casselman River at Confluence, Pa., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
July 8	Hoyt and Hall	230	279	0.80	1.65	224
September 12	E. C. Murphy	194	123	.36	1.50	44
September 27	N. C. Grover	220	107	.27	1.49	29

Mean daily gage height, in feet, of Casselman River at Confluence, Pa., for 1904.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1	.....	1.40	1.45	1.55	17	1.55	1.50	1.45	[b]1.60
2	.....	1.40	1.45	1.55	18	1.50	1.50	1.45	(a)
3	.....	1.40	1.45	1.55	19	1.45	1.45	1.45	(a)
4	.....	1.35	1.45	1.55	20	1.45	1.40	1.50	(a)
5	.....	1.35	1.40	1.55	21	1.55	1.50	1.50	(a)
6	.....	1.35	1.40	1.55	22	1.50	1.50	1.50	(a)
7	.....	1.35	1.40	1.55	23	1.45	1.50	1.50	(a)
8	.....	1.40	1.40	1.55	24	1.45	1.50	1.55	[b]1.95
9	.....	1.45	1.40	1.55	25	1.45	1.50	1.55	[c]3.35
10	.....	1.45	1.40	1.55	26	1.50	1.50	1.55	2.70
11	.....	1.50	1.40	(a)	27	1.50	1.45	1.55	2.95
12	.....	1.50	1.40	(a)	28	1.45	1.45	1.55	4.10
13	.....	1.50	1.40	(a)	29	1.45	1.45	1.55	3.00
14	.....	1.60	1.40	(a)	30	1.45	1.45	1.55	2.05
15	.....	1.60	1.40	(a)	31	.....	1.45	.....	2.15
16	1.55	1.55	1.40	(a)					

[a] Ice. [b] Hole cut in ice and gage read to surface of water. [c] Ice gone out

LAUREL HILL CREEK AT CONFLUENCE, PA.

This station was established September 15, 1904, by E. C. Murphy. It is located at the highway bridge near the tannery, about one-fourth of a mile from the railroad station at Confluence, Pa. A standard chain gage is fastened to the downstream hand rail of the bridge. The length of the chain from the end of the weight to the marker is 17.55 feet. Bench mark No. 1 is a cross on the top of a bolt in the bed plate of the bridge at the right abutment. Its elevation is 14.16 feet above the datum of the gage. Bench mark No. 2 is a cross on the lower chord of the bridge under the gage box. Its elevation is 14.74 feet above the gage datum. Discharge measurements are made from the lower side of the single-span steel bridge to which the gage is

attached. The initial point for soundings is the center of the bridge pin over the left abutment on the left side of the bridge. The channel is straight for about 25 feet above and for 300 feet below the station. The current is swift. The right bank is low, clean, and subject to overflow during high water. The left bank is high and not subject to overflow. The bed of the stream is composed of rough cobblestones and is permanent. There is one channel at all except freshet stages. The gage is read daily by L. L. Mountain.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Laurel Hill Creek at Confluence, Pa., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
July 8	Hoyt and Hall	83	156	0.80	2.14	125
September 12	E. C. Murphy	80	91	.30	1.78	27
September 27	N. C. Grover	84	84	.19	1.75	16

Mean daily gage height, in feet, of Laurel Hill Creek at Confluence, Pa., for 1904.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1	.....	1.65	1.60	1.70	17	1.80	1.70	1.70	1.80
2	.....	1.65	1.60	1.70	18	1.70	1.65	1.70	1.85
3	.....	1.60	1.60	1.70	19	1.65	1.60	1.70	1.85
4	.....	1.60	1.60	1.70	20	1.65	1.60	1.70	1.85
5	.....	1.60	1.60	1.70	21	1.70	1.60	1.70	1.85
6	.....	1.60	1.60	1.70	22	1.70	1.60	1.70	1.85
7	.....	1.60	1.65	1.70	23	1.65	1.60	1.70	1.90
8	.....	1.65	1.65	1.70	24	1.65	1.60	1.70	[b]3.00
9	.....	1.65	1.65	1.70	25	1.65	1.70	1.70	3.35
10	.....	1.65	1.65	1.70	26	1.65	1.70	1.70	2.70
11	.....	1.80	1.65	[a]1.70	27	1.75	1.65	1.70	3.40
12	.....	1.80	1.65	1.75	28	1.75	1.65	1.70	3.60
13	.....	1.80	1.65	1.75	29	1.70	1.65	1.70	3.00
14	.....	1.75	1.65	1.75	30	1.65	1.60	1.70	2.50
15	.....	1.70	1.65	1.80	31	.....	1.60	.....	2.40
16	1.80	1.70	1.65	1.80					

[a] River frozen from December 11 to 23. [b] Ice gone out.

MAHONING RIVER DRAINAGE BASIN.

Mahoning River rises in the northwestern part of Columbiana County, Ohio, flows north, then turns southeast, entering Ohio River at Beaver, in Beaver County, Pa. This river flows through a hilly and important territory. There are numerous water-power developments on it, and it forms an important adjunct in the water supply and sewage disposal of numerous towns along its course. Among

them is Youngstown, Ohio, where the United States Geological Survey station is maintained. Its drainage area at Youngstown is 958 square miles.

MAHONING RIVER AT YOUNGSTOWN, OHIO.

This station was established May 23, 1903, by R. Winthrop Pratt, and is located about 2 miles below the center of the city of Youngstown, at the highway bridge near the plant of the Hazelton Steel Company. The vertical gage, consisting of a 1-inch by 6-inch board nailed to stakes driven in the river bed 15 feet from the east abutment, was used up to September 23, 1903, at which time a standard chain gage was installed, having a length of 25.36 feet from the end of the weight to the marker. The gage is read once each day by John McVean. Discharge measurements are made from the single-span highway bridge, to which the gage is attached. The initial point for soundings is the face of the parapet wall of the east abutment on the upstream side. The channel is straight for about 800 feet above and 200 feet below the bridge and is 200 feet wide between abutments. Both banks are high and are subject to overflow only at high water. The section is fairly regular and the bed of the stream is composed of gravel and small bowlders, probably not subject to change.

Bench mark No. 1 is the top of the copper plate on the face of the east abutment near the upstream corner. It is 9.37 feet above gage datum. Bench mark No. 2 is the northwest corner of the bridge seat of the west abutment. It is 17.12 feet above gage datum. Bench mark No. 3 is a cut in the end stone of the second tier from the top of the north wing wall of the west abutment. It is 21.34 feet above gage datum. Bench mark No. 4 is a cut in the top hand rail at a point 35 feet from the east abutment on the upstream side. It is 25.88 feet above gage datum. The elevation of the center of the pulley on which the chain of the gage runs is 23.61 feet above gage datum.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Mahoning River at Youngstown, Ohio, in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
January 27	R. W. Pratt	162	654	2.16	2.50	1,413
March 8	do	192	1,624	4.50	7.80	7,322
April 16	do	152	503	1.38	1.86	694
May 18	do	144	393	.56	1.07	219
July 26	do	150	361	.45	.80	164
August 24	do	155	437	1.04	1.35	455
September 15	do	135	335	.21	.65	66
November 3	do	153	360	.30	.74	108

Mean daily gage height, in feet, of Mahoning River at Youngstown, Ohio, for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.00	1.30	10.00	13.00	5.40	9.00	0.60	0.96	0.88	0.53	0.71	0.67
2	1.05	1.20	10.00	12.60	4.10	11.40	.80	.77	.65	.43	.70	.66
3	.90	1.00	9.80	7.00	3.00	10.10	.80	.81	.62	.35	.72	.64
4	.85	1.10	9.10	3.10	2.50	4.70	.80	.71	.60	.35	.71	.68
5	.70	1.20	8.80	2.50	1.90	2.90	1.10	.78	.58	.61	.68	.68
6	.70	1.30	5.20	2.20	1.60	2.20	1.30	.70	.82	.65	.59	.70
7	.70	7.20	5.70	2.20	1.40	1.80	2.40	.76	.75	.61	.59	.78
8	.85	10.10	7.90	2.10	1.30	1.50	2.60	.72	.65	.45	.67	.65
9	.80	10.00	5.70	2.70	1.30	1.40	2.20	.68	.80	.34	.67	.50
10	.70	5.50	4.00	3.40	1.20	1.40	1.90	.67	.68	.52	.70	.60
11	.70	3.50	2.80	2.70	1.10	1.30	1.40	.78	.60	.55	.75	.60
12	.80	2.20	2.50	2.40	1.10	1.20	1.40	.76	.72	.66	.70	.52
13	.80	1.90	2.00	2.20	1.00	1.10	1.30	.75	.80	.62	.55	.58
14	.90	1.50	1.90	2.10	1.00	1.00	1.20	.78	.82	.59	.80	.72
15	.80	1.30	1.70	1.90	1.10	1.00	1.20	.77	.66	.55	.71	.70
16	.70	1.30	1.60	1.80	1.00	.90	1.20	.75	.61	.55	.70	.71
17	.90	1.00	1.50	1.70	1.10	.90	1.10	.71	.62	.65	.70	.60
18	.80	.90	2.70	1.70	1.20	.70	1.00	.69	.44	.61	.75	.40
19	.90	.90	4.40	1.60	3.10	.70	.80	.70	.65	.70	.50	.48
20	1.20	.80	4.70	1.50	4.50	.90	.80	.98	.68	.50	.71	.50
21	4.30	1.00	4.40	1.40	3.30	1.10	.80	.94	.62	.58	.73	.45
22	14.15	1.60	3.40	1.30	2.20	1.40	.70	1.00	.52	.80	.71	.50
23	17.45	1.80	5.40	1.20	1.90	1.40	.70	1.40	.50	.51	.55	.63
24	15.00	2.40	4.90	1.20	4.50	1.30	.60	1.25	.58	.56	.64	.70
25	9.70	1.90	3.50	1.50	4.70	1.10	.60	1.17	.46	.55	.62	1.00
26	4.50	1.50	9.20	2.50	5.50	.80	.70	2.05	.72	.57	.50	1.40
27	3.60	1.90	10.20	3.70	10.10	.80	.85	2.25	.50	.56	.50	2.48
28	2.50	.90	8.30	3.90	8.70	.70	.87	1.52	.58	.72	.62	3.20
29	2.30	1.00	5.40	4.80	4.40	.70	.90	1.15	.45	.81	.64	1.81
30	2.00	.....	3.50	7.10	2.80	.60	.69	1.02	.41	.60	.65	1.80
31	1.50	.....	3.50	.....	3.30	.....	.61	.93	.....	.64	.....	1.82

[a] Ice conditions January and February.

Rating table for Mahoning River at Youngstown, Ohio, from May 23, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.5	8	1.9	750	3.6	2,010	8.5	9,100
.6	52	2.0	810	3.8	2,190	9.0	10,120
.7	98	2.1	880	4.0	2,390	9.5	11,170
.8	146	2.2	950	4.2	2,610	10.0	12,240
.9	195	2.3	1,020	4.4	2,830	10.5	13,400
1.0	245	2.4	1,090	4.6	3,070	11.0	14,600
1.1	295	2.5	1,160	4.8	3,310	11.5	15,800
1.2	345	2.6	1,230	5.0	3,550	12.0	17,000
1.3	395	2.7	1,300	5.5	4,200	13.0	19,400
1.4	450	2.8	1,370	6.0	4,870	14.0	21,800
1.5	510	2.9	1,450	6.5	5,620	15.0	24,200
1.6	570	3.0	1,530	7.0	6,420		
1.7	630	3.2	1,690	7.5	7,270		
1.8	690	3.4	1,850	8.0	8,140		

The foregoing table is applicable only for open-channel conditions. It is based upon 15 discharge measurements made during 1903 and 1904. It is well defined between gage heights 0.9 foot and 2 feet. The table has been extended beyond these limits. The curve is very unsatisfactory below 0.9 foot gage height. This is probably due to the dam below this station; at low stages the water may even fall below the crest of the dam. Above gage height 10.4 feet the rating curve is a tangent, the difference being 240 per tenth.

Estimated monthly discharge of Mahoning River at Youngstown, Ohio, for 1904.

[Drainage area, 958 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
March	12,700	510	4,726	4.93	5.68
April	19,400	345	2,615	2.73	3.05
May	12,470	245	1,959	2.04	2.35
June	15,560	52	1,686	1.76	1.96
July	1,230	52	310	.324	.374
August	985	84	236	.246	.284
September	185	1	70.2	.073	.081
October	151	0	47.3	.049	.056
November	146	8	79.6	.083	.093
December	1,690	0	228	.238	.274

MUSKINGUM RIVER DRAINAGE BASIN.

Muskingum River is formed by the junction of Walhonding and Tuscarawas rivers in the east-central part of Ohio, flows south, and enters Ohio River at Marietta, Ohio. In this drainage basin the United States Geological Survey operates a station on Licking River at Pleasant Valley, Ohio.

LICKING RIVER AT PLEASANT VALLEY, OHIO.

This station was established November 14, 1902, by Benjamin H. Flynn. It is located at the highway bridge, 300 feet north of the railroad station at Pleasant Valley, Ohio. A standard chain gage is attached to the bridge. The length of the chain from the end of the weight to the marker is 20.93 feet. The gage is read once each day by A. B. Lebold. Low-water measurements are made by wading, and high-water measurements from the bridge to which the gage is attached. The channel is straight for 200 feet above and 500 feet below the station. The banks are high and not liable to overflow, except in extreme floods. The bed of the stream is composed of gravel and clay. Bench mark No. 1 is three copper nails driven into a willow tree about 400 feet to the right of the right end of the bridge, arranged in a vertical position, and having elevations respectively 14.92, 15.92, and 16.92 feet above the datum of the gage. Bench mark No. 2 is a nail driven into the outside guard timber near the gage box and has an elevation of 21.52 feet above the datum of the gage.

The drainage area at Pleasant Valley is 696 square miles. Licking River flows into the Muskingum at Zanesville, Ohio.

Discharge measurements of Licking River at Pleasant Valley, Ohio, in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
May 7	R. W. Pratt	66	249	1.65	2.61	412
May 23	do	61	204	1.59	2.32	324
June 27 [a]	do	74	53	3.31	1.74	176
July 2 [a]	do	95	77	2.17	1.75	167
July 16	do	177	176	2.40	2.90	422
August 27	do	65	61	2.68	1.87	163
September 24 [a]	do	53	36	2.00	1.54	72
October 29 [a]	do	71	61	2.75	2.00	168
November 26 [a]	do	53	35	2.23	1.56	78

[a] Wading.

Mean daily gage height, in feet, of Licking River at Pleasant Valley, Ohio., for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.[b]
1	2.80	3.40	4.90	10.80	4.10	9.00	1.80	2.00	1.80	1.55	2.05	1.50
2	2.70	3.20	4.10	13.50	3.80	5.80	1.80	2.20	1.90	1.55	2.05	1.50
3	2.40	3.00	5.30	7.00	3.50	4.40	1.70	2.10	1.80	1.50	2.10	1.50
4	2.20	2.90	7.70	5.20	3.30	3.50	1.70	2.00	1.80	1.50	2.10	1.50
5	2.30	2.90	4.10	4.30	3.10	3.00	1.70	1.90	1.80	1.50	2.10	1.50
6	2.30	3.00	3.30	4.20	2.90	2.70	1.70	1.90	1.70	1.75	2.10	1.55
7	2.40	4.70	7.10	3.90	2.80	2.50	9.20	1.80	1.70	1.65	1.90	1.55
8	2.40	8.90	6.50	3.70	2.60	2.40	14.80	1.80	1.70	1.60	1.80	1.55
9	2.50	5.40	4.90	3.80	2.50	2.30	6.80	1.80	1.70	1.60	1.60	1.55
10	2.50	4.00	3.80	3.70	2.40	2.20	5.30	1.80	1.60	1.70	1.60	1.60
11	2.50	3.20	3.50	3.50	2.30	2.20	4.30	1.80	1.60	2.55	1.60	.....
12	2.40	2.90	3.30	3.50	2.30	2.10	3.90	1.70	1.60	2.05	1.60	.....
13	2.40	2.80	3.30	3.40	2.20	2.00	4.60	1.70	1.60	1.90	1.60	.....
14	2.30	2.70	3.10	3.30	2.20	2.00	4.00	1.70	1.60	1.80	1.60	.....
15	2.30	2.60	3.70	3.20	2.20	1.90	3.30	1.70	1.60	1.75	1.55	.....
16	2.30	2.60	3.30	3.10	2.20	1.90	3.00	1.70	1.60	1.70	1.55	1.70
17	2.30	2.60	3.40	2.90	2.20	2.00	2.80	1.90	1.60	1.65	1.55	.....
18	2.40	2.50	3.50	2.80	2.20	1.90	2.60	1.80	1.60	1.60	1.55	.....
19	2.40	2.40	4.90	2.60	2.30	1.90	2.50	1.80	1.60	1.60	1.55	.....
20	2.50	2.40	4.00	2.50	2.30	2.00	2.40	1.80	1.60	1.60	1.55	.....
21	2.60	2.30	3.60	2.50	2.30	2.00	2.30	1.80	1.60	1.60	1.55	.....
22	14.25	8.70	3.80	2.50	2.20	2.60	2.30	1.80	1.60	1.60	1.55	.....
23	13.20	6.90	5.30	2.40	2.20	2.30	2.20	1.80	1.60	1.60	1.55	1.75
24	7.80	8.70	5.00	2.40	2.40	2.00	2.20	1.80	1.60	1.60	1.55	2.40
25	4.80	5.40	3.90	2.40	2.30	1.90	2.10	1.70	1.60	1.55	1.55	2.75
26	4.60	3.80	7.50	5.20	2.70	1.80	2.00	2.70	1.60	1.55	1.55	2.60
27	4.50	3.60	12.20	6.10	2.50	1.80	2.00	2.00	1.60	1.60	1.50	3.80
28	4.50	3.60	6.40	5.30	2.30	1.70	2.00	1.80	1.60	1.80	1.50	3.40
29	4.40	3.50	4.80	5.40	2.10	1.90	3.70	1.80	1.55	2.00	1.50	3.30
30	4.00	.....	4.20	4.70	2.20	1.90	2.30	1.80	1.55	2.00	1.50	3.10
31	3.70	.....	6.60	.....	2.60	.....	2.10	1.70	.....	2.00	.....	2.80

[a] Ice conditions January and February. [b] River frozen December 10 to 25.

Rating table for Licking River at Pleasant Valley, Ohio, from November 14, 1902, to July 9, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.2	72	2.5	375	3.8	935	6.5	2,610
1.3	77	2.6	412	3.9	985	7.0	2,960
1.4	86	2.7	450	4.0	1,035	7.5	3,310
1.5	99	2.8	490	4.2	1,140	8.0	3,660
1.6	116	2.9	530	4.4	1,250	9.0	4,360
1.7	136	3.0	570	4.6	1,360	10.0	5,060
1.8	159	3.1	610	4.8	1,480	11.0	5,760
1.9	184	3.2	655	5.0	1,600	12.0	6,460
2.0	211	3.3	700	5.2	1,725	13.0	7,160
2.1	240	3.4	745	5.4	1,855	14.0	7,860
2.2	271	3.5	790	5.6	1,985		
2.3	304	3.6	835	5.8	2,120		
2.4	339	3.7	885	6.0	2,260		

The above table is applicable only for open-channel conditions. It is based upon 9 discharge measurements made during 1902 to 1904, inclusive.

The channel changed during flood July 7 to 9, 1904. After this date use the following table.

Rating table for Licking River at Pleasant Valley, Ohio, from July 10 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.4	54	2.2	230	3.0	510	3.8	860
1.5	66	2.3	260	3.1	550	3.9	910
1.6	81	2.4	290	3.2	590	4.0	960
1.7	99	2.5	320	3.3	630	4.2	1,080
1.8	120	2.6	350	3.4	670	4.4	1,200
1.9	143	2.7	390	3.5	710	4.6	1,320
2.0	170	2.8	430	3.6	760	4.8	1,440
2.1	200	2.9	470	3.7	810	5.0	1,560

The above table is applicable only for open-channel conditions. It is based upon 5 discharge measurements made during 1904. It is well defined between gage heights 1.25 feet and 3 feet. The table has been extended beyond these limits. Above gage height 5 feet the rating curve is a tangent, the difference being 70 per tenth.

Estimated monthly discharge of Licking River at Pleasant Valley, Ohio, for 1904.

[Drainage area, 696 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
March	6,600	610	1,618	2.32	2.68
April	7,510	339	1,361	1.96	2.19
May	1,085	240	408	.586	.676
June	4,360	136	.502	.721	.804
July	8,440	136	913	1.31	1.51
August	390	99	137	.197	.227
September	143	74	90.2	.130	.145
October	335	66	107	.154	.178
November	194	66	102	.147	.164
December[a]	2,120	66	277	.398	.459

[a] December estimates assumed same as open channel.

KANAWHA RIVER DRAINAGE BASIN.

Kanawha River, which rises in Watauga, Ashe, and Alleghany counties, N. C., flows northwesterly through Virginia and West Virginia, and joins Ohio River at Point Pleasant, W. Va. In its upper course it is known as New River. The headwaters lie in the Appalachian Mountains, among the high ridges which form the divides between

the drainage basin of this river and Yadkin River on the east, and of Holston River on the west. The upper tributaries drain narrow valleys of the mountainous region of North Carolina and their slopes are generally steep and their beds are rough. The main river cuts the Alleghany fronts just below Pearisburg, Va.; thence the river's course is through a narrow valley of West Virginia, over a rough bed with many falls and rapids. The basin is as beautiful and picturesque as any in the eastern part of the United States. The country on its lower courses, through which the Cheasapeake and Ohio Railway passes, is noted for its scenic beauty. Below the junction with the Gauley the river is known as the Kanawha.

The principal tributaries of New River are Little River, which empties near Radford, Va., and the Greenbrier, which rises in the eastern part of West Virginia and joins the New at Hinton, W. Va. The following is a list of the stations maintained during 1904 in this drainage basin by the United States Geological Survey: New River at Fayette, W. Va.; Greenbrier River at Alderson, W. Va.; New River at Radford, Va.

NEW RIVER AT RADFORD, VA.

This station is located at the highway bridge near the Norfolk and Western Railway station, and was established by D. C. Humphreys August 1, 1898. The gage used at first was erected by the United States Weather Bureau. It consists of a vertical board graduated to feet and tenths, and is attached to the iron framework connecting the pair of iron concrete cylinders, which form the first pier from the right bank. On account of the inaccessibility of the Weather Bureau gage, a wire gage was put in February 23, 1900, the datum being the same as that of the old gage. On December 1, 1903, the old wire gage was replaced by a standard chain gage, which was installed by W. C. Sawyer. At this time the gage datum was lowered 3.41 feet. The length of the chain from the end of the weight to the marker is 87 feet. The observer is T. M. Brady, saddler and harness dealer, who reads the gage twice daily. The channel is straight for several hundred feet above and below the station and has a width of 580 feet at ordinary stages, broken by five piers. At high water its width is about 1,200 feet. The bottom is of solid rock and gravel and is smooth and regular. On the left bank there is a steep, rocky bluff. The right bank is low and subject to overflow for about 100 yards, but all the water must pass under the bridge, which is about 85 feet above low water. The discharge measurements are made from the upstream side of the bridge. The initial point for soundings is on the right bank of the river, 50 feet from the first pier.

The bench marks described below are all referred to the datum of the chain gage. Bench mark No. 1 is the bottom of the lowest horizontal brace connecting the two cylinders; elevation, 7.28 feet. Bench

mark No. 2 is the top of the lowest horizontal brace on the west side of the bridge, 2.5 feet south of the northwest post of the bent nearest the river on the right bank; elevation, 22.66 feet. Bench mark No. 3 is the northwest corner of the top of the stone under the seventh post from the right bank; elevation, 18.58 feet.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of New River at Radford, Va., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
June 18	F. H. Brundage	530	1,833	1.87	4.07	3,436
September 16	R. H. Bolster	520	1,411	1.10	3.40	1,553
September 29	do	520	1,330	.88	3.24	1,177
October 18	do	518	1,280	.75	3.14	954

Mean daily gage height, in feet, of New River at Radford, Va., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.50	3.40	4.20	4.10	4.00	4.80	4.70	3.70	3.30	3.20	3.10	3.20
2	3.70	3.60	4.30	4.00	3.80	6.50	4.30	4.00	3.70	3.10	3.10	3.20
3	3.60	3.50	4.20	4.00	3.70	5.70	4.10	4.30	3.80	3.10	3.20	3.20
4	3.40	3.60	4.20	4.00	3.70	2.90	3.90	4.40	3.80	3.10	3.20	3.40
5	3.40	3.70	4.20	3.90	4.50	2.90	4.00	4.30	3.60	3.10	3.20	3.40
6	3.30	3.70	4.10	3.90	4.40	3.30	4.10	4.60	3.50	3.10	3.30	3.70
7	3.30	4.00	4.00	3.90	4.10	4.10	4.10	4.00	3.30	3.10	3.60	4.10
8	3.40	4.80	7.40	3.80	4.00	4.20	3.90	3.90	3.30	3.10	3.40	3.70
9	3.40	4.80	5.50	3.80	4.00	4.30	3.80	4.10	3.40	3.10	3.30	3.60
10	3.40	4.50	5.00	4.20	5.50	4.00	4.00	4.20	3.80	3.10	3.20	3.50
11	3.40	4.20	4.60	4.10	4.80	3.80	4.30	4.70	3.30	3.10	3.10	3.50
12	3.50	3.50	4.40	4.00	4.40	4.00	4.00	4.60	3.30	3.10	3.10	3.50
13	3.50	3.50	4.40	4.00	4.10	4.20	3.80	4.20	3.30	3.00	3.50	3.40
14	3.50	3.20	4.30	3.90	3.90	4.00	3.60	4.00	3.30	3.00	3.70	3.40
15	3.50	3.50	4.20	4.00	3.90	3.80	3.60	3.90	3.30	3.00	3.60	3.30
16	3.50	3.60	4.00	3.80	4.10	4.30	3.60	3.90	3.30	3.00	3.50	3.20
17	3.40	3.80	3.80	3.70	4.10	4.00	3.50	3.90	3.30	3.00	3.50	3.20
18	3.40	3.80	3.80	3.70	4.20	4.00	3.50	3.80	3.30	3.00	3.40	3.40
19	3.40	3.70	3.30	3.60	6.30	4.00	3.40	3.70	3.30	3.00	3.40	3.20
20	3.50	3.30	3.70	3.60	5.20	4.50	3.40	3.60	3.30	3.00	3.40	3.10
21	3.50	3.50	3.70	3.50	4.90	4.10	3.30	3.60	3.20	3.00	3.30	3.10
22	3.80	4.50	3.70	3.50	4.70	3.90	3.30	3.60	3.20	3.00	3.30	3.10
23	5.40	5.30	3.60	3.50	4.50	3.80	3.50	3.70	3.20	3.00	3.20	3.10
24	4.80	4.90	3.90	3.50	4.30	3.70	3.60	3.60	3.20	3.00	3.20	3.30
25	4.30	4.40	4.90	3.50	3.90	3.60	3.70	3.50	3.20	3.00	3.20	3.50
26	3.80	3.90	4.70	3.50	4.00	3.70	3.80	3.50	3.20	3.10	3.20	3.60
27	3.60	3.90	4.70	3.70	4.00	3.90	3.80	3.50	3.20	3.10	3.20	3.50
28	3.40	3.80	4.60	3.90	3.90	3.70	3.90	3.50	3.20	3.10	3.20	3.60
29	3.20	4.10	4.40	4.00	3.80	5.90	4.00	3.40	3.20	3.10	3.20	3.50
30	2.90	.....	4.20	3.90	3.60	5.40	4.50	3.40	3.20	3.10	3.20	3.40
31	3.10	.....	4.00	.....	3.60	.....	4.10	3.30	.....	3.10	.....	3.30

Rating table for New River at Radford, Va., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.0	690	4.0	3,220	5.0	6,830	6.0	11,500
3.1	895	4.1	3,540	5.1	7,245	6.2	12,550
3.2	1,105	4.2	3,870	5.2	7,670	6.4	13,610
3.3	1,325	4.3	4,205	5.3	8,110	6.6	14,690
3.4	1,555	4.4	4,550	5.4	8,560	6.8	15,790
3.5	1,800	4.5	4,905	5.5	9,020	7.0	16,910
3.6	2,055	4.6	5,270	5.6	9,490	7.2	18,050
3.7	2,325	4.7	5,645	5.7	9,975	7.4	19,200
3.8	2,610	4.8	6,030	5.8	10,470		
3.9	2,910	4.9	6,425	5.9	10,980		

The above table is applicable only for open-channel conditions. It is based upon discharge measurements made during 1898 to 1904, inclusive, special weight being given to 1904 measurements. It is well defined between gage heights 3 feet and 4.1 feet.

Estimated monthly discharge of New River at Radford, Va., for 1904.

[Drainage area, 2,725 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	8,560	485	2,114	0.776	0.895
February	8,110	1,105	3,150	1.16	1.25
March	19,200	1,325	4,525	1.66	1.91
April	3,870	1,800	2,689	.987	1.10
May	13,080	2,055	4,217	1.55	1.79
June	14,150	485	4,071	1.49	1.66
July	5,645	1,325	2,802	1.03	1.19
August	5,645	1,325	2,941	1.08	1.24
September	2,610	1,105	1,418	.520	.580
October	1,105	690	816	.299	.345
November	2,325	895	1,340	.492	.549
December	3,540	895	1,570	.576	.664
The year	19,200	485	2,638	.968	13.17

NEW RIVER AT FAYETTE, W. VA.

This station, established by C. C. Babb and D. C. Humphreys July 29, 1895, is located just below the mouth of Wolf Creek, on the highway bridge of one span at Fayette, W. Va. The wire gage was located on the guard rail on the upper side of the bridge, about the middle of the span, the scale being graduated to feet and tenths. The gage is referred to four bench marks: First, the top of the bottom plate of the lower plate girder at the end of the first panel from the right bank, downstream side, 55.13 feet above the zero of the gage; second, the

top of the lower end of the coping on the main pier, right bank, downstream side, 52.08 feet above the zero of the gage; third, the bridge seat on the right bank, downstream side, 54.54 feet above the zero of the gage; fourth, the west corner of the abutment stone by the Chesapeake and Ohio Railway station, 58.56 feet above the zero of the gage. A temporary bench mark, established when the chain gage was installed, is the top of the bottom plate of the plate girder 0.5 foot south of the gage box. Its elevation is 52.57 feet above gage datum. The channel is straight above and below the station. The current is swift and without obstructions, except for immense bowlders in the bottom. The banks are high, rocky, and not subject to overflow. The bed is constant in section. The observer is J. R. Durrett, a clerk in the store at Fayette, W. Va. The station was discontinued May 22, 1901. On August 11, 1902, it was reestablished. On November 20, 1903, a standard chain gage was installed by W. C. Sawyer. It occupies the same position as the old wire gage, which it replaced, and it has the same datum. The length of the chain from the end of the weight to the marker is 59 feet. The station was discontinued December 31, 1904.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Mean daily gage height, in feet, of New River at Fayette, W. Va., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.60	1.20	8.00	4.20	7.20	3.80	8.33	2.59	0.55	−0.08	−0.31	0.05
2	1.90	1.10	9.50	4.80	6.10	5.00	7.17	1.81	.75	− .12	− .25	.05
3	1.90	1.60	8.20	5.30	5.20	9.30	4.65	1.60	.75	− .19	− .23	.10
4	1.90	1.50	7.50	4.80	4.70	9.50	4.04	3.12	1.60	− .27	− .04	.15
5	1.80	2.00	7.00	4.20	5.00	7.40	3.42	2.70	2.25	− .35	− .04	.25
6	1.90	2.40	6.10	3.70	4.50	5.90	3.01	3.40	1.75	(a)	− .06	1.00
7	1.90	2.60	5.90	3.60	5.10	4.90	3.65	2.55	1.50	− .41	.05	1.88
8	1.60	4.40	10.00	3.40	4.50	4.30	3.10	3.41	1.10	− .50	.68	2.70
9	1.40	8.00	12.20	3.40	4.00	4.00	3.30	2.30	.55	− .54	.86	2.69
10	1.00	7.00	9.20	3.40	4.00	4.10	2.86	2.20	.65	− .41	.59	2.03
11	1.30	5.00	7.30	4.10	4.80	4.20	3.66	2.30	.65	− .45	.31	1.85
12	1.30	3.70	6.40	3.80	5.20	4.00	3.97	2.40	.40	− .45	.11	1.66
13	1.40	2.80	(a)	3.70	4.30	3.70	3.33	3.56	.52	− .37	.09	1.36
14	1.20	2.10	5.70	3.50	3.80	4.40	2.55	3.16	.40	− .27	.24	.77
15	1.10	2.30	5.30	3.50	3.40	3.40	2.15	2.55	.32	− .37	.32	.73
16	.90	1.70	5 20	3.60	3.30	(a)	1.60	2.10	.38	− .29	.60	.70
17	.80	1.60	4.90	3.50	3.40	3.07	1.50	1.95	.40	− .37	1.23	.00
18	.70	1.60	4 40	3.40	3.80	3.11	1.45	1.56	.35	− .42	.99	1.11
19	.70	1.70	4 00	3.30	8.30	3.05	1.27	2.35	.35	− .42	.75	.55
20	1.00	1.70	4.00	3.10	13.30	3.10	1.02	2.00	.25	.46	.57	.91
21	1.70	2.30	3.80	3.00	10.10	3.68	.86	2 00	.17	− .14	.44	.95
22	2.00	5.10	3.70	2.70	(a)	3.50	.81	1.75	.04	− .37	.46	.85
23	5.30	10 50	5.00	2.50	6.60	3.10	.60	1.55	.00	− .42	.50	.73
24	9.90	9.20	7.30	2.50	6.10	2.82	1.27	1.55	.00	− .21	.39	.80
25	7 40	7.80	7.30	2.50	6.80	2.50	1.01	1.45	−.04	− .37	.35	1.12
26	5.50	6.40	7.60	2.80	6.20	2.05	1.45	1.20	− .05	− .37	.40	1.15
27	4 00	5.10	6.90	5.30	5.80	1.99	1.72	1.05	−.06	− .37	.25	(a)
28	2.80	4.80	6.30	10.30	5.40	3.56	1.90	.85	−.15	− .17	.30	3.22
29	2.20	6.00	5.80	10.30	4.50	6.10	2.17	.75	−.08	− .33	.25	2.98
30	1.70	.....	5.10	8.60	4.00	6.15	2.30	.65	−.06	− .20	.08	2.72
31	1.40	.....	4.60	.....	3.90	.....	3.36	.50	.....	− .29	.....	2.37

a Observer absent.

Estimated monthly discharge of New River at Fayette, W. Va., for 1904.

[Drainage area, 6,200 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	22,800	1,755	4,519	0.729	0.840
February	24,600	2,190	7,790	1.26	1.36
March	29,700	6,806	13,340	2.15	2.48
April	24,000	4,479	8,229	1.33	1.48
May	33,000	6,021	11,070	1.79	2.06
June	21,600	3,566	8,321	1.34	1.50
July	18,090	1,665	5,133	.828	.955
August	6,530	1,580	3,746	.604	.696
September	4,022	1,155	1,698	.274	.306
October	1,192	984	1,070	.173	.200
November	2,362	1,075	1,484	.239	.267
December	5,866	1,240	2,646	.427	.492
The year	33,000	984	5,754	.929	12.64

NOTE.—The above estimate can only be considered as approximate. It is based upon the 1902 rating table with some modification below 2 feet gage height.

GREENBRIER RIVER AT ALDERSON, W. VA.

Greenbrier River rises on the western slope of the Allegheny Mountains, in Pocahontas County, W. Va., and flows in a southwesterly direction, emptying into New River near Hinton, Summers County, W. Va. It receives many short tributaries from the Allegheny Range, and flows for the most part through a broken, hilly, and mountainous country well covered with forests. This station, which is 21 miles above Hinton, was established by C. C. Babb and D. C. Humphreys August 1, 1895. It is located one-half mile above the mouth of Muddy Creek, at the highway bridge in the village of Alderson. The wire gage which was originally installed was located in the third panel of the second span, downstream side of the bridge. This gage was referred to three bench marks: The first, on the upper end of the coping of the first pier from the left bank, 21.74 feet above gage datum; the second, on the upper end of the bridge seat of the left-bank abutment, 21.61 feet above gage datum; the third, on the stone foundation of the water tank of the Chesapeake and Ohio Railway, 23.48 feet above gage datum. A temporary bench mark has been established on the lower end of the third floor beam, in the second span from the left bank. Its elevation is 22.72 feet above gage datum. On November

20, 1903, a standard chain gage was installed by W. C. Sawyer. It occupies the same position as the wire gage which it replaced, and its datum is the same. The length of the chain from the end of the weight to the marker is 27.81 feet. A new bench mark, to which this gage is referred, is the top of the water table at the northwest corner of the Merchants' Grocery Company building. Its elevation is 21.71 feet above gage datum. The channel, which is straight for 500 feet above and below the station, is broken at the bridge by three piers. At low stages the water flows in two channels, between which is an island 600 feet long and 75 feet wide. The initial point for soundings is the center of the pin on the downstream side of the bridge, on the left bank. The banks are high and not subject to overflow. The bed is of rock and gravel and fairly constant. The observer is W. J. Hancock, merchant at Alderson, W. Va., who reads the gage once daily.

The observations at this station during 1904 have been made under the direction of N. C. Grover, district hydrographer.

Discharge measurements of Greenbrier River at Alderson, W. Va., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Sq. feet.	*Ft. per. sec.*	*Feet.*	*Second-ft.*
June 15	F. H. Brundage	390	1.26	2.20	490
August 9	N. C. Grover	256	.57	1.72	146
September 20	R. H. Bolster	251	.45	1.63	114
October 1	do	196	.26	1.44	51
October 20	do	217	.35	1.51	76

Mean daily gage height, in feet, of Greenbrier River at Alderson, W. Va., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.88	2.35	4.65	3.30	3.90	3.00	2.70	1.75	1.55	1.40	1.60	1.[illegible]
2	1.90	2.42	5.60	4.20	3.60	3.60	2.50	1.70	1.60	1.40	1.55	1.[illegible]
3	2.27	2.20	4.70	4.10	3.40	4.40	2.35	1.60	1.55	1.40	1.45	1.[illegible]
4	2.67	1.98	4.40	3.70	3.60	5.25	2.25	1.60	1.55	1.40	1.50	1.[illegible]
5	2.93	2.10	3.45	3.35	3.80	3.75	2.25	1.70	1.55	1.40	1.55	1.[illegible]
6	2.60	1.90	3.65	3.10	3.10	3.15	2.25	1.75	1.55	1.40	1.50	1.70
7	2.32	2.20	3.40	3.00	3.00	3.00	2.20	1.80	1.55	1.45	1.40	1.80
8	2.20	5.25	6.10	2.95	2.90	2.85	2.20	1.80	1.55	1.50	1.50	1.85
9	2.22	4.50	5.30	2.95	2.80	2.75	2.20	1.70	1.55	1.60	1.45	1.85
10	2.20	3.60	4.35	3.00	2.75	2.65	2.15	1.70	1.55	1.55	1.40	1.75
11	2.10	3.20	3.70	3.00	2.65	2.60	2.10	1.70	1.55	1.60	1.40	1.70
12	2.08	2.80	3.50	3.00	2.65	2.50	2.20	1.75	1.55	1.50	1.50	1.65
13	2.00	2.65	3.50	2.95	2.55	2.45	2.00	1.65	1.60	1.50	1.50	1.65
14	1.97	2.45	3.30	2.95	2.45	2.35	2.00	1.75	1.60	1.50	1.50	1.70
15	1.90	2.32	3.25	2.90	2.45	2.25	1.95	1.70	1.55	1.45	1.60	1.75
16	2.15	2.50	3.40	2.80	2.50	2.20	1.90	1.65	1.50	1.45	1.60	1.75
17	2.12	2.90	3.10	2.80	2.55	2.25	1.85	1.65	1.50	1.40	1.60	1.60
18	2.08	2.10	3.00	2.75	2.65	2.20	1.80	1.70	1.55	1.50	1.60	1.60
19	1.92	2.00	2.90	2.65	7.80	2.15	1.80	1.70	1.50	1.50	1.60	1.60
20	1.85	2.40	2.90	2.65	5.85	2.15	1.80	1.70	1.65	1.50	1.50	1.70
21	1.90	2.45	2.85	2.60	4.75	2.10	1.80	1.75	1.80	1.50	1.55	1.65
22	2.20	5.10	2.85	2.55	4.45	2.10	1.70	1.80	1.50	1.50	1.60	1.65
23	7.70	5.90	3.75	2.45	3.65	2.25	1.70	1.70	1.50	1.45	1.60	1.70
24	5.40	4.60	5.30	2.40	3.45	2.15	1.75	1.80	1.55	1.40	1.60	1.60
25	4.00	4.45	4.40	2.35	3.45	2.20	1.70	1.80	1.50	1.50	1.60	1.75
26	3.25	3.75	3.85	2.45	3.35	2.10	1.80	1.70	1.50	1.45	1.60	2.40
27	3.08	3.25	3.55	3.45	3.20	2.20	1.80	1.65	1.50	1.40	1.60	3.30
28	3.10	2.95	3.45	5.70	3.05	2.40	1.85	1.60	1.60	1.40	1.60	3.20
29	3.15	3.55	3.20	5.00	2.85	2.50	1.80	1.60	1.50	1.40	1.60	3.10
30	2.90	.....	2.95	4.45	2.75	2.85	1.75	1.55	1.40	1.40	1.55	2.85
31	2.63	.....	2.85	.....	2.80	.....	1.75	1.55	.....	1.40	.....	2.50

Rating table for Greenbrier River at Alderson, W. Va., from January 1, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.4	46	2.6	1,000	3.8	3,440	6.0	9,300
1.5	70	2.7	1,160	3.9	3,680	6.5	10,830
1.6	101	2.8	1,330	4.0	3,920	7.0	12,400
1.7	140	2.9	1,510	4.2	4,400	7.5	14,000
1.8	188	3.0	1,700	4.4	4,890	8.0	15,600
1.9	246	3.1	1,900	4.6	5,390	8.5	17,270
2.0	315	3.2	2,110	4.8	5,900	9.0	19,000
2.1	396	3.3	2,320	5.0	6,420	9.5	20,700
2.2	490	3.4	2,540	5.2	6,960	10.0	22,500
2.3	598	3.5	2,760	5.4	7,530	10.5	24,400
2.4	720	3.6	2,980	5.6	8,110	11.0	26,500
2.5	855	3.7	3,210	5.8	8,700		

The preceding table is applicable only for open-channel conditions. It is based upon discharge measurements made during 1897 to 1904, inclusive. It is well defined between gage heights 1.4 feet and 2.4 feet, being determined between these limits by 1903 and 1904 measurements. Above 2.4 feet the table is fairly accurate to 6 feet, being determined above 6 feet by three measurements made in 1897. Above 9 feet the table is the same as the 1902 table.

Estimated monthly discharge of Greenbrier River at Alderson, W. Va., for 1903 and 1904.

[Drainage area, 1,344 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1903.					
January	22,290	577	3,711	2.76	3.18
February	23,620	1,700	6,567	4.89	5.10
March	30,700	1,160	6,063	4.51	5.20
April	9,600	1,900	3,298	2.45	2.73
May	2,540	315	864	.643	.741
June	8,400	396	1,702	1.27	1.42
July	2,386	128	754	.561	.647
August	788	58	239	.178	.205
September	301	79	161	.120	.134
October	246	101	149	.111	.128
November	246	70	150	.112	.125
December	490	101	183	.136	.157
The year	30,700	58	1,987	1.48	19.77
1904.					
January	14,640	217	1,529	1.14	1.31
February	9,000	246	2,247	1.67	1.80
March	9,600	1,420	3,515	2.62	3.02
April	8,400	659	2,219	1.65	1.84
May	14,960	788	2,715	2.02	2.33
June	7,100	396	1,328	.988	1.10
July	1,160	140	352	.262	.302
August	188	86	141	.105	.121
September	188	46	86.4	.064	.071
October	101	46	60.5	.045	.052
November	101	46	83.4	.062	.069
December	2,320	70	412	.307	.354
The year	14,960	46	1,224	.911	12.37

SCIOTO RIVER DRAINAGE BASIN.

Scioto River rises in the eastern part of Auglaize County, Ohio, flows east for about 40 miles and then almost due south, entering the Ohio at Portsmouth. Below Columbus, where it is joined by the Olentangy, it is one of the largest and most important streams in the State. The United States Geological Survey maintained stations on both Scioto and Olentangy rivers at Columbus for the purpose of studying the water supply and sewage disposal of that city. The river has considerable fall and flows through a hilly basin, forming numerous good locations for water-power developments. Its drainage area at Columbus is 1,051 square miles.

SCIOTO RIVER NEAR COLUMBUS, OHIO.

This station was originally established for the Ohio State board of health by B. F. Flynn, on the Grand View Avenue Bridge, 3 miles northwest of Columbus post-office, and was reestablished on the same bridge by R. W. Pratt, on November 21, 1903. This bridge is a two-span iron highway bridge, 250 feet between abutments. The initial point for soundings is the face of the easterly abutment on the down-stream side, and the bridge is marked every 10 feet with double nails. The main channel is straight for about 100 feet above and 200 feet below, and there is a small island 150 feet above, which causes a side channel to enter the main channel at this point. The banks are high and only overflow in extreme floods. At low water the river is sluggish, but can be waded at several points below the bridge, where good measurements can be obtained. The following bench marks have been established:

Bench mark No. 1 is the upper side of the upper angle iron forming the lowest part of the hand rail above a point 1 foot east of the pulley. This point is 34.02 feet above the zero of the gage. Bench mark No. 2 is the extreme northeast corner of the north stone of the parapet wall of the east abutment, the elevation of which is 34.32 feet above the zero of the gage. Bench mark No. 3 is a nail in a telegraph pole 10 feet east of the east abutment at the north side, having an elevation of 34.95 feet above the zero of the gage. The gage established by Mr. Pratt has its zero at the same elevation as the gage which was established by Mr. Flynn. It consists of a regulation chain and weight, with a length of 30.40 feet from the end of the weight to the end of the last copper link, which is used as the marker.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Scioto River near Columbus, Ohio, in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
January 18[a]	R. W. Pratt	36	39	1.31	[b]9.70	51
January 22[c]	do	225	3,344	5.43	23.40	18,120
February 29[c]	do	246	2,187	2.66	17.60	5,827
March 4	do	228	3,373	3.98	20.40	13,400
March 26	do	233	3,426	5.66	23.40	19,400
April 4	do	235	2,247	4.31	18.00	9,691
May 14	do	123	278	.76	9.81	210
June 3	do	180	571	1.62	11.14	927
July 21	do	132	317	.76	9.87	241
August 6	do	100	207	.24	9.12	50
August 6[d]	do	84	68	.81	9.12	55
September 3[d]	do	91	78	.46	9.04	36
October 22[d]	do	77	75	.47	9.10	35
November 19[d]	do	15	10.5	1.36	8.89	14.3
December 16	do	16	13.5	1.33	9.08	18

[a] Wading 600 feet above bridge.
[b] Ice caused gage to read about 0.50 too high.
[c] Ice and débris.
[d] Wading 800 feet above bridge.

Mean daily gage height, in feet, of Scioto River near Columbus, Ohio, for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	9.80	14.10	16.00	21.30	12.05	10.00	9.77	9.55	9.03	9.08	9.15	9.13
2	9.80	13.30	16.00	24.30	11.70	10.42	9.95	9.55	9.02	9.01	9.00	9.12
3	9.85	11.90	19.00	20.80	11.45	10.75	10.10	9.19	8.97	9.00	8.97	9.13
4	9.80	11.95	20.65	17.95	11.25	10.55	10.00	9.16	8.97	9.28	8.97	9.12
5	9.70	11.95	17.80	16.10	10.78	10.50	10.05	9.12	9.05	9.48	9.17	9.15
6	9.75	12.75	16.15	14.45	10.55	10.37	16.02	9.33	9.00	9.27	9.15	9.20
7	9.70	17.95	14.35	13.10	10.40	10.10	16.45	9.10	9.06	9.16	9.32	9.06
8	9.75	16.15	13.55	12.65	10.25	9.95	15.05	9.03	9.03	9.27	9.15	9.28
9	9.80	14.85	13.10	12.55	10.20	9.80	17.60	9.00	9.08	9.12	9.25	9.13
10	9.70	14.35	12.55	12.50	10.10	9.70	15.48	9.10	9.03	9.10	9.13	9.15
11	9.70	13.60	12.35	12.30	10.00	9.60	13.85	9.15	9.12	9.10	9.31	9.10
12	9.70	12.50	12.15	12.15	9.90	9.52	13.02	9.12	9.04	9.10	9.18	9.14
13	9.70	12.40	12.45	12.00	9.80	9.50	12.25	9.08	9.00	9.11	9.17	9.22
14	9.65	14.15	12.55	11.80	9.82	9.45	11.70	9.10	8.97	9.08	9.08	9.11
15	9.70	14.35	12.20	11.55	9.80	9.45	11.32	9.12	8.96	9.15	8.90	9.20
16	9.70	13.30	11.35	11.15	9.78	9.45	11.20	9.15	9.02	9.08	9.05	9.10
17	9.70	13.15	11.50	10.83	9.72	9.50	10.45	9.01	9.04	9.05	9.09	9.05
18	9.70	12.70	11.70	10.65	9.80	9.47	10.67	8.87	8.98	8.98	9.08	9.00
19	9.70	12.40	12.80	10.50	9.80	9.50	10.07	9.01	9.04	9.27	9.10	.....
20	9.75	12.50	12.70	10.30	9.85	9.95	9.82	9.15	9.10	9.07	9.10	.....
21	15.40	12.35	12.65	10.15	9.87	9.80	9.72	9.10	8.97	9.05	9.16	9.20
22	23.35	15.50	12.50	10.10	9.90	9.82	9.61	9.22	8.96	9.00	9.32	9.22
23	21.60	15.15	13.70	10.10	9.95	10.25	9.55	8.86	9.00	9.00	9.28	9.30
24	17.15	15.40	13.90	9.95	10.00	10.52	9.50	8.87	8.94	9.05	9.02	9.30
25	14.80	14.55	23.45	10.05	9.85	10.42	9.47	8.90	8.94	9.00	9.10	9.35
26	13.75	13.85	23.45	12.60	9.70	10.15	9.40	9.32	8.92	9.00	8.95	9.45
27	13.60	13.65	20.00	12.85	9.80	9.87	9.38	9.20	8.92	9.05	9.00	11.10
28	15.35	13.55	17.25	12.60	9.80	9.75	9.31	9.05	8.96	9.00	8.95	10.05
29	15.05	15.80	15.10	12.35	9.72	10.00	9.35	9.09	8.94	8.87	9.05	9.85
30	14.55	.....	13.60	12.25	9.75	9.82	9.29	9.02	9.07	8.81	9.15	10.65
31	14.10	.....	15.35	.....	9.83	.....	9.39	8.97	.....	9.00	.....	10.45

[a] Ice conditions during January and February.

Rating table for Scioto River near Columbus, Ohio, from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
8.8	6	10.1	285	11.8	1,000	16.5	7,000
8.9	16	10.2	310	12.0	1,160	17.0	7,890
9.0	29	10.3	335	12.2	1,340	17.5	8,790
9.1	45	10.4	360	12.4	1,540	18.0	9,690
9.2	64	10.5	385	12.6	1,740	18.5	10,590
9.3	86	10.6	410	12.8	1,940	19.0	11,490
9.4	110	10.7	440	13.0	2,140	20.0	13,290
9.5	135	10.8	470	13.5	2,680	21.0	15,090
9.6	160	10.9	500	14.0	3,230	22.0	16,890
9.7	185	11.0	530	14.5	3,860	23.0	18,690
9.8	210	11.2	620	15.0	4,560	24.0	20,490
9.9	235	11.4	730	15.5	5,330		
10.0	260	11.6	860	16.0	6,150		

The above table is applicable only for open-channel conditions. It is based upon 15 discharge measurements made during 1903 and 1904. It is well defined between gage heights 9 feet and 15 feet. The table has been extended beyond these limits. Above gage height 16.6 feet the rating curve is a tangent, the difference being 180 per tenth. The curve includes measurements made during 1899, 1900, and 1903, but the changes due to measurements of 1904 make it applicable only to the above limits.

Estimated monthly discharge of Scioto River near Columbus, Ohio, for 1904.

[Drainage area, 1,051 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
March	19,500	700	5,180	4.93	5.68
April	21,030	248	3,205	3.05	3.40
May	1,205	185	331	.315	.363
June	455	122	243	.231	.258
July	8,970	84	1,445	1.38	1.59
August	148	12	50.9	.048	.055
September	49	19	30.3	.029	.032
October	130	7	44.5	.042	.048
November	91	16	48.7	.046	.051
December	570	29	110	.105	.121

OLENTANGY RIVER NEAR COLUMBUS, OHIO.

This station was established October 7, 1903, by R. Winthrop Pratt, in connection with the water supply and sewage disposal investigations of the city of Columbus. It is located 4 miles north of the Columbus, Ohio, post-office and one-fourth mile west of North High street at the Doddridge Street Bridge. The boxed chain gage is bolted to the hand rail of the bridge on the upstream side. The observer is A. D. Winegardner. Discharge measurements are made from the two-span highway bridge and by wading below the bridge. The initial point for soundings is the east face of the west parapet wall. The channel is straight for 300 feet above and 500 feet below the station. The banks overflow only at high stages. The bed of the stream is of sand and clay. The drainage area at the station is 520 square miles.

Bench mark No. 1 is the northwest corner of the top stone of the north wing of the west abutment. Its elevation is 34.99 feet above gage datum. Bench mark No. 2 is a cut in the top of the hand rail over the gage 31 feet from the initial point for soundings. Its elevation is 39.89 feet above the zero of the gage. Bench mark No. 3 is the center pin of the west end of the north truss, the elevation of which is 38.60 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction af E. Johnson, jr., district hydrographer.

Discharge measurements at regular stations on Olentangy River near Columbus, Ohio, in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
January 16[a]	R. W. Pratt	70	36	1.00	6.40	36
January 22	do	186	2,445	5.73	19.40	14,000
February 5[a b]	do	78	60	1.55	6.90	93
February 22[c]	do	120	510	3.09	9.40	1,575
February 25[c]	do	118	530	2.89	9.35	1,529
March 5	do	151	1,104	3.15	11.50	3,469
March 19	do	144	856	1.81	9.20	1,569
April 23[a]	do	43	53	2.66	7.10	140
May 28[a]	do	84	86	2.64	7.22	226
June 4	do	137	570	0.44	7.35	249
July 23[a]	do	50	50	1.24	6.80	62
August 20[a]	do	31	12	1.16	6.56	14
September 30[a]	do	20.5	7.2	0.97	6.52	7
October 28[a]	do	24	10.9	1.87	6.70	20.4
November 12[a]	do	19.5	9.2	1.16	6.59	10.7
December 23[a]	do	28	13.6	1.29	6.66	17.5

[a] Wading at different sections. [b] Ice. [c] At Lane avenue, three-fourths mile below station.

Mean daily gage height, in feet, of Olentangy River near Columbus, Ohio, for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.[b]
1	6.50	6.60	13.40	16.30	8.20	8.20	7.20	6.70	6.50	6.50	6.60	6.[illegible]
2	6.50	6.60	11.60	19.60	8.20	7.70	7.10	6.60	6.60	6.50	6.60	6.[illegible]
3	6.40	6.50	14.80	12.30	7.80	7.60	7.00	6.60	6.75	6.50	6.55	6.[illegible]
4	6.40	6.50	15.80	9.80	7.60	7.40	7.00	6.60	6.70	6.50	6.60	[illegible]
5	6.40	6.60	12.30	8.70	7.50	7.20	7.00	6.60	6.70	6.55	6.60	6.[illegible]
6	6.50	9.00	9.20	8.40	7.30	7.20	7.00	6.60	6.65	6.60	6.60	6.[illegible]
7	6.50	11.20	9.30	8.10	7.20	7.00	13.05	6.60	6.60	6.55	6.60	6.[illegible]
8	6.50	13.10	9.90	7.90	7.20	6.90	11.70	6.60	6.95	6.50	6.60	6.[illegible]
9	6.50	10.40	9.00	7.90	7.10	6.90	12.50	6.60	6.90	6.55	6.60	6.[illegible]
10	6.40	9.00	8.30	8.10	7.10	6.90	10.00	6.60	6.80	6.65	6.55	6.[illegible]
11	6.40	7.40	8.00	8.00	7.00	6.80	8.50	6.60	6.70	6.70	6.55	6.[illegible]
12	6.40	7.50	7.90	7.70	7.00	6.80	8.00	6.60	6.60	6.80	6.60	[illegible]
13	6.40	7.60	7.70	7.80	7.00	6.80	7.60	6.60	6.60	6.80	6.60	[illegible]
14	6.40	7.20	7.50	7.70	7.00	6.80	7.50	6.60	6.70	6.60	6.60	[illegible]
15	6.40	7.40	7.70	7.70	7.00	6.80	7.20	6.60	6.60	6.60	6.60	[illegible]
16	6.40	7.40	7.50	7.50	7.00	7.00	7.20	6.60	6.60	6.60	6.60	6.[illegible]
17	6.40	7.00	7.50	7.30	7.00	7.00	7.10	6.60	6.60	6.70	6.60	6.[illegible]
18	6.40	6.90	8.00	7.30	7.20	6.90	7.00	6.60	6.60	6.65	6.60	6.[illegible]
19	6.40	6.60	9.40	7.20	7.00	6.80	6.90	6.60	6.60	6.65	6.65	6.[illegible]
20	6.40	6.70	8.90	7.20	7.10	8.00	6.90	6.60	6.60	6.70	6.60	6.[illegible]
21	9.20	6.70	8.00	7.10	7.10	7.10	6.90	6.55	6.60	6.60	6.60	.....
22	20.40	8.80	8.40	7.10	7.20	7.00	6.80	6.50	6.60	6.65	6.60	. ....
23	18.90	9.70	10.20	7.10	7.30	7.00	6.80	6.55	6.60	6.60	6.60	6.[illegible]
24	16.20	10.00	10.20	7.10	7.20	7.00	6.70	6.50	6.60	6.60	6.60	6.[illegible]
25	14.40	9.20	9.70	7.10	7.10	7.20	6.60	6.50	6.60	6.60	6.60	6.[illegible]
26	9.40	8.20	16.80	9.50	7.50	7.20	6.60	6.85	6.50	6.65	6.60	6.[illegible]
27	7.40	7.90	15.40	9.80	7.30	7.10	6.70	6.80	6.50	6.60	6.60	[illegible]
28	7.20	7.90	11.80	9.40	7.30	7.00	6.70	6.55	6.50	6.60	6.60	[illegible]
29	7.50	10.20	9.20	8.80	7.20	7.50	6.70	6.60	6.50	6.65	6.60	7.[illegible]
30	7.00	.....	8.50	8.50	7.20	7.50	6.80	6.60	6.50	6.60	6.60	7.[illegible]
31	6.60	.....	11.00	.....	7.60	.....	6.70	6.60	.....	6.60	.....	7.[illegible]

[a] Ice conditions January and February. [b] Frozen December 7 to 31.

Rating table for Olentangy River near Columbus, Ohio, from October 7, 1903, to January 22, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
6.2	13	6.6	55	7.0	133	7.3	234
6.3	21	6.7	69	7.1	163	7.4	275
6.4	31	6.8	85	7.2	197	7.5	320
6.5	43	6.9	107				

During the flood of January 22, 1904, the channel shifted, changing the curve below gage height 7.5 feet, as shown in succeeding table. Above gage height 7.5 the two tables are alike.

Rating table for Olentangy River near Columbus, Ohio, from January 23 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
6.5	5	8.0	600	9.5	1,630	12.0	3,950
6.6	20	8.1	660	9.6	1,710	12.5	4,500
6.7	39	8.2	720	9.7	1,790	13.0	5,100
6.8	62	8.3	780	9.8	1,870	13.5	5,700
6.9	89	8.4	840	9.9	1,950	14.0	6,300
7.0	118	8.5	910	10.0	2,030	14.5	6,950
7.1	150	8.6	980	10.2	2,210	15.0	7,600
7.2	185	8.7	1,050	10.4	2,390	15.5	8,300
7.3	225	8.8	1,120	10.6	2,570	16.0	9,000
7.4	270	8.9	1,190	10.8	2,750	16.5	9,700
7.5	320	9.0	1,260	11.0	2,940	17.0	10,400
7.6	370	9.1	1,330	11.2	3,140	18.0	11,900
7.7	425	9.2	1,400	11.4	3,340	19.0	13,400
7.8	480	9.3	1,470	11.6	3,540		
7.9	540	9.4	1,550	11.8	3,740		

The above table is applicable only for open-channel conditions. It is based upon 14 discharge measurements made during 1904. It is well defined between gage heights 6.2 feet and 11.5 feet. The table has been extended beyond these limits. Above gage height 17 feet the rating curve is a tangent, the difference being 150 per tenth.

Estimated monthly discharge of Olentangy River near Columbus, Ohio, for 1904.

[Drainage area, 520 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
March	10,120	320	2,501.	4.81	5.54
April	14,300	150	1,516.	2.92	3.26
May	720	118	232.	.446	.514
June	720	62	187.	.360	.402
July	5,160	20	634.	1.22	1.41
August	76	5	21.5	.041	.047
September	104	5	27.4	.053	.059
October	62	5	23.3	.045	.052
November	30	12	19.5	.038	.042

LITTLE MIAMI RIVER DRAINAGE BASIN.

Little Miami River rises in the southeastern part of Clark County, flows southwest through Greene and Warren counties, and enters Ohio River just above Cincinnati. The greater part of the drainage area lies to the east, as there is only a narrow piece of country between this and Miami River. The Little Miami is the best power river in the State of Ohio. The United States Geological Survey maintained a station on the Little Miami at Morrow in 1903, where its drainage area is 951 square miles. In 1904 a gaging station was operated on Mad River near Springfield.

MAD RIVER NEAR SPRINGFIELD, OHIO.

This station was established December 31, 1903, by R. Winthrop Pratt. It is located at a highway bridge 4 miles west of Springfield, Ohio, and about 500 feet below old Red Mill dam. A standard chain gage is spiked to the bridge. The length of the chain from the end of the weight to the marker is 16.05 feet. The gage is read once each day by Charles W. Smith. Discharge measurements are made from the downstream side of the single-span bridge to which the gage is fastened. The bridge has a length between abutments of 128 feet. The channel is practically straight for 1,000 feet above and below the station, there being a slight curve just above. The right bank is high, clean, and seldom overflows. The left bank is rather low and is subject to overflow. The bed of the stream is composed of a mixture of clay and gravel and is fairly permanent. Bench mark No. 1 is on the extreme west corner of the second stepstone on the upstream side of the north side of the bridge. Its elevation is 15.88 feet above the datum of the gage. Bench mark No. 2 is on the top of the bottom of the gage box. Its elevation is 19.67 feet above the datum of the gage. Bench mark No. 3 is a nail in top of lower chord, 87 feet from initial point. Its elevation is 18.69 feet above gage datum.

The drainage area at this station is 290 square miles.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Mad River near Springfield, Ohio, in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
January 30	R. W. Pratt	55	224	1.50	6.40	334
February 27	do	60	292	1.80	6.60	547
March 25	do	99	701	3.65	10.20	2,559
April 9	do	63	337	2.43	6.90	820
June 25	do	65	239	1.10	5.82	262
July 30[a]	do	82	80	2.17	5.65	174
August 30[a]	do	97	92	1.50	5.56	138
September 23[a]	do	96	95	1.34	5.50	127
October 18[a]	do	95	99	1.47	5.59	145
November 17[a]	do	96	117	1.28	5.64	150
December 28[a]	do	130	939	.43	6.50	407

[a] Wading 500 feet above bridge.

Mean daily gage height, in feet, of Mad River near Springfield, Ohio, for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	6.10	6.30	7.90	13.50	6.30	6.00	6.80	5.80	5.60	5.55	5.60	5.65
2	6.10	6.40	6.90	11.90	6.30	6.00	6.10	5.70	5.55	5.55	5.60	5.68
3	6.30	6.30	9.60	8.80	6.20	5.90	5.80	5.60	5.55	5.55	5.60	5.67
4	6.40	6.30	9.20	7.40	6.20	5.90	5.80	5.60	5.60	5.60	5.60	5.62
5	6.40	6.30	9.30	7.10	6.10	5.80	5.80	5.60	5.50	5.50	5.60	5.63
6	6.30	6.70	7.00	7.00	6.00	5.80	6.50	5.50	5.52	5.55	5.65	5.60
7	6.30	10.90	7.00	6.90	6.00	5.80	6.90	5.50	5.50	5.55	5.60	5.60
8	6.30	8.90	6.90	6.80	6.00	5.80	6.90	5.50	5.50	5.55	5.60	5.60
9	6.30	8.00	6.60	6.90	6.10	5.80	7.30	5.50	5.50	5.60	5.60	5.60
10	6.30	6.50	6.50	6.70	6.00	5.80	6.40	5.50	5.50	5.55	5.60	5.65
11	6.30	6.70	6.90	6.60	5.90	5.80	6.20	5.50	5.50	5.85	5.70	5.60
12	6.20	6.50	6.70	6.60	5.90	5.70	6.10	5.50	5.45	5.70	5.65	5.62
13	6.10	6.40	6.50	6.50	5.90	5.70	6.00	5.50	5.50	5.70	5.60	5.60
14	5.90	6.30	6.60	6.50	5.90	5.70	5.80	5.50	5.60	5.65	5.60	5.60
15	6.10	6.10	6.50	6.50	6.10	5.70	5.80	5.50	5.15	5.60	5.60	5.60
16	6.00	6.30	6.50	6.40	6.00	5.80	5.80	5.50	5.50	5.60	5.60	5.63
17	5.90	6.20	6.50	6.30	5.90	5.90	5.80	5.50	5.50	5.60	5.60	5.63
18	6.00	6.20	7.50	6.30	6.00	5.90	5.90	5.40	5.50	5.56	5.60	5.62
19	6.00	6.10	7.00	6.30	6.00	5.80	5.80	5.50	5.50	5.60	5.65	5.70
20	6.10	6.10	6.80	6.20	5.90	7.00	5.80	5.70	5.32	5.60	5.60	5.60
21	12.00	6.20	6.70	6.10	6.30	6.30	5.70	5.70	5.50	5.60	5.60	5.60
22	14.10	8.70	6.60	6.10	6.10	6.10	5.70	5.60	5.55	5.65	5.60	5.60
23	11.80	8.00	7.70	6.10	6.10	5.90	5.70	5.60	5.50	5.65	5.60	5.70
24	8.40	9.50	7.20	6.10	6.00	5.80	5.60	5.50	5.45	5.60	5.65	6.10
25	7.30	7.30	9.30	6.10	6.00	5.80	5.70	5.50	5.70	5.60	5.63	6.20
26	6.70	6.70	15.40	7.00	5.90	5.80	5.70	5.80	5.60	5.60	5.67	6.20
27	6.60	6.50	12.00	6.70	6.10	5.80	5.60	5.70	5.60	5.60	5.65	7.90
28	6.00	8.20	8.30	6.60	6.00	5.80	5.50	5.50	5.60	5.60	5.65	6.35
29	6.60	8.50	7.50	6.60	5.90	6.10	5.60	5.50	5.60	5.60	5.65	6.15
30	6.50	.....	8.90	6.50	5.90	5.90	5.50	5.50	5.50	5.65	5.65	6.15
31	6.40	.....	11.45	.....	5.90	.....	5.50	5.53	.....	5.60	.....	5.95

[a] Ice conditions January and February.

WABASH RIVER DRAINAGE BASIN.

The drainage basin of the Wabash embraces an area of about 33,000 square miles, distributed as follows: In Ohio, 400 square miles; in Indiana, 24,350 square miles; in Illinois, 8,250 square miles. It drains, therefore, slightly more than two-thirds of Indiana, the area of the State being 35,910 square miles. Of the portion of Indiana, about one-half is embraced in the drainage areas of East and West White rivers. By including these drainage areas with the Wabash, the entire basin has a nearly symmetrical, broadly ovate form. Not including the White River system, the Wabash basin is an unsymmetrical, elongated tract, curving around White River.

The length of the valley occupied by the Wabash is about 450 miles, but the length of the stream is fully 500 miles, for the river in its lower course makes several oxbow curves within the valley. The source of the river is about 1,000 feet above tide, while its mouth at low water is but 311 feet. The average fall, if we estimate the stream to have a length of 500 miles, is therefore about 16.5 inches per mile. The rate of descent is far from uniform, being much more rapid in the upper portion than in the lower. There are also many rapids, separated by pools or sluggish portions of the stream. The elevation of the stream is accurately determined at many points, but in the absence of a careful measurement of the length of the stream the rate of fall is only approximately known. The section above the point where the river enters the old lake outlet, estimated to have a length of 100 miles, has a fall of about 300 feet, or 3 feet per mile. Railway levels and canal surveys at the point where the river joins the old lake outlet show its elevation to be nearly 700 feet above sea level, the altitudes reported varying between 696 and 699 feet.

The following table gives the elevation and fall at various points in this basin:

Table of altitudes and distances along Wabash River.

Location.	Estimated distance.	Altitude.	Fall per mile.
	Miles.	*Feet.*	*Feet.*
Source	0.0	1,000.0	0.00
Huntington	100.0	699.0	36.00
Mouth of Salamonie River	15.0	667.0	25.56
Mouth of Mississinewa River	20.0	633.0	20.40
Logansport	20.0	583.0	30.00
Lafayette	50.0	506.0	18.48
Attica	25.0	487.0	9.12
Covington	20.0	470.0	10.20
Terre Haute	55.0	447.7	4.80
State line	14.6	440.6	5.80
Hutsonville, Ill	29.0	424.6	6.60
Vincennes	46.4	398.8	6.60
Mouth of White River	32.5	376.5	8.30
Grayville, Ill	28.0	365.0	5.00
Mouth of Little Wabash	46.0	323.0	11.00
Mouth of Wabash River	16.0	311.0	9.00

During 1904 the United States Geological Survey maintained stations in this basin at Logansport, Delphi, Indianapolis, Cataract, and Shoals. The following are the drainage areas of the several streams at these points.

Drainage areas in Wabash River basin.

	Sq. miles.
Wabash River at Logansport	3,163
Tippecanoe River near Delphi	1,890
Lower Eel River at Cataract	255
White River (East Branch) at Shoals	4,900
White River (West Branch) at Indianapolis	1,520

WABASH RIVER AT LOGANSPORT, IND.

This station was established April 27, 1903, by George E. Waesche. It is located at the Cicott Street Bridge, about 1 mile from the center of the city of Logansport, 1¾ miles from the Wabash Railroad station, 1½ miles from the Pennsylvania station, four blocks from the street car line, and 1,000 feet below the mouth of Eel River. A standard chain gage is placed on the second span of the bridge, at the third panel from the second pier, and is supported by the bridge pins, and is between the lower chord bars. It is reached through a trap door in the floor planks of the bridge. The distance from the end of the weight to the marker is 20.78 feet. The gage is read once each day by W. R. Allison. Discharge measurements are made from the

upstream side of the bridge to which the gage is attached. The initial point for soundings is the inner face of the left abutment. The channel is nearly straight for 1,000 feet above and for 1,500 feet below the station. The distance between abutments is 550 feet, and the channel is broken by three bridge piers. The right bank is high, and is not subject to overflow at the bridge. The left bank is submerged only at extreme high water. The bed of the stream consists of solid rock covered with small bowlders and is rough and permanent. The stream is shallow and the current is never sluggish.

Bench mark No. 1 is the top of the north abutment, under the fourth board of the downstream sidewalk. Its elevation above gage datum is 18.814 feet. From Pennsylvania Railroal levels its elevation above sea level has been found to be 591 feet. Bench mark No. 2 is the top of the third course of masonry from the top of the north abutment. Its elevation above the zero of the gage is 15.31 feet.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Wabash River at Logansport, Ind., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft*
April 27	G. E. Waesche		978	2.42	2.50	2,367
June 8	do		2,060	3.49	4.55	7,180
June 16	do					1,444
July 8	do		829	1.64	2.30	1,358
July 16	E. C. Murphy		669	1.08	1.54	719
August 15	E. Johnson, jr		576	.72	1.35	418
September 30	L. R. Stockman		491	.71	1.30	349
November 10	do		610	.74	1.38	452
December 28[a]	E. Johnson, jr		1,024	1.25	2.75	1,285
1904.						
January 22[b]	F. W. Hanna	528	6,721	6.95	13.11	46,690
March 2[c]	do	536	4,210	5.62	8.20	23,660
March 29[c]	do	536	5,335	6.09	10.50	32,480
May 3	F. W. Hanna and Johnson.		1,536	2.44	2.98	3,744
June 17	F. W. Hanna	483	810	1.08	1.66	878
July 21	do	477	814	1.13	1.76	920
August 23	do	478	753	.96	1.50	723
September 14	do	446	637	.85	1.48	542
October 21	do	426	574	.70	1.30	402
November 4	do	420	558	.68	1.27	379

[a] Partly frozen. [b] Float measurement. [c] Some floating ice.

Mean daily gage height, in feet, of Wabash River at Logansport, Ind., for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.[a]	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.[a]
1	2.53	3.10	9.90	12.22	3.75	2.90	1.80	1.30	1.30	1.35	.....	1.30
2	2.50	3.00	7.88	13.00	3.25	3.00	1.73	1.30	1.33	1.35	1.22	1.35
3	2.33	2.30	7.65	13.02	2.95	3.00	1.75	1.35	1.27	1.30	1.25	1.45
4	2.23	2.50	7.88	11.06	2.75	2.90	1.68	1.33	1.21	1.29	1.27	1.22
5	2.23	2.50	7.30	7.65	2.58	2.70	1.76	1.30	1.25	1.26	1.23	1.28
6	2.20	3.00	6.50	5.73	2.50	2.40	1.90	1.35	1.30	1.25	1.25	1.22
7	2.20	10.20	8.19	4.88	2.40	2.30	3.10	1.29	1.24	1.28	1.27	1.22
8	2.15	9.65	7.35	4.45	2.30	2.20	5.12	1.29	1.20	1.35	1.27	1.28
9	2.15	7.90	5.83	4.70	2.30	2.00	4.95	1.32	1.25	1.45	1.22	1.25
10	2.15	6.35	5.00	4.95	2.35	1.90	4.71	1.25	1.25	1.46	1.30	1.18
11	2.15	5.60	5.00	4.70	2.25	1.90	4.43	1.25	1.25	1.46	1.30	1.31
12	2.10	5.10	5.15	4.68	2.13	1.82	4.14	1.24	1.25	1.45	1.30	1.20
13	2.10	4.20	.....	4.30	2.10	1.78	3.53	1.20	1.26	1.45	1.30	1.40
14	2.20	3.60	4.20	3.90	.....	1.73	2.99	1.25	1.48	1.40	1.31	.....
15	2.20	2.70	3.70	3.60	.....	1.70	2.69	1.21	1.41	1.37	1.31	.....
16	2.15	2.50	3.42	3.38	2.00	1.70	2.50	1.25	1.25	1.35	1.25	.....
17	2.15	2.30	3.45	3.15	1.95	1.65	2.00	1.25	1.30	1.35	1.31	.....
18	2.20	2.34	5.40	2.90	2.00	1.73	1.99	1.25	1.41	1.29	1.30	.....
19	2.25	2.38	6.75	2.90	2.15	1.75	1.85	1.25	1.49	1.28	1.30	.....
20	2.60	2.10	7.00	2.63	2.40	1.90	1.81	1.50	1.49	1.25	1.33	.....
21	10.85	2.25	6.20	2.52	2.40	2.56	1.78	1.61	1.51	1.30	1.35	.....
22	13.19	2.21	8.30	2.48	2.35	3.30	1.65	1.76	1.39	1.30	1.35	.....
23	12.55	2.35	8.10	2.85	2.43	3.15	1.65	1.50	1.37	1.30	1.30	1.31
24	10.00	3.50	6.68	2.15	2.40	2.97	1.61	1.45	1.37	1.30	1.28	1.35
25	7.45	4.80	6.85	2.60	2.40	2.49	1.55	1.40	1.40	1.30	1.31	1.41
26	6.00	4.50	13.45	7.05	2.75	2.20	1.53	1.29	1.56	1.30	1.30	1.50
27	4.75	3.70	14.84	7.12	2.70	2.00	1.53	1.30	1.50	1.30	1.30	1.73
28	4.38	3.88	13.05	5.90	2.53	1.93	1.50	1.27	1.56	1.24	1.34	.....
29	4.00	9.22	10.32	5.25	2.40	1.87	1.50	1.30	1.46	1.22	1.30	4.12
30	3.70	.....	7.50	4.50	2.43	1.80	1.41	1.33	1.40	1.22	1.28	3.96
31	3.50	.....	9.10	.....	2.55	.....	1.39	1.34	.....	.....	.....	3.41

[a] Ice conditions January 1 to March 3 and December 14 to 31.

Rating table for Wabash River at Logansport, Ind., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.2	260	2.5	2,540	4.2	7,380	8.0	22,770
1.3	360	2.6	2,770	4.4	8,050	8.5	25,060
1.4	480	2.7	3,010	4.6	8,730	9.0	27,410
1.5	620	2.8	3,260	4.8	9,430	9.5	29,790
1.6	770	2.9	3,510	5.0	10,140	10.0	32,200
1.7	930	3.0	3,770	5.2	10,880	10.5	34,650
1.8	1,100	3.1	4,030	5.4	11,640	11.0	37,130
1.9	1,280	3.2	4,300	5.6	12,420	12.0	42,130
2.0	1,470	3.3	4,580	5.8	13,220	13.0	47,130
2.1	1,670	3.4	4,870	6.0	14,040	14.0	52,130
2.2	1,880	3.6	5,460	6.5	16,170	15.0	57,130
2.3	2,090	3.8	6,080	7.0	18,320		
2.4	2,310	4.0	6,720	7.5	20,520		

The preceding table is applicable only for open-channel conditions. It is based upon 19 discharge measurements made during 1903 and 1904. It is well defined between gage heights 1.3 feet and 8.2 feet. The table has been extended beyond these limits. Above gage height 10.7 feet the rating curve is a tangent, the difference being 500 per tenth.

Estimated monthly discharge of Wabash River at Logansport, Ind., for 1904.

[Drainage area, 3,163 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimun.	Mean.	Second-feet per square mile.	Depth in inches.
March 4–31	56,140	4,928	19,900	6.29	6.55
April	47,130	1,775	12,860	4.06	4.53
May	5,925	1,375	2,440	.771	.889
June	4,580	850	6,146	1.94	2.16
July	10,580	468	2,673	.845	.974
August	1,032	260	409	.128	.148
September	710	260	439	.139	.155
October	566	280	392	.124	.143
November	420	280	349	.110	.123

TIPPECANOE RIVER NEAR DELPHI, IND.

This station was established March 14, 1903, by George E. Waesche. The station is located at the highway bridge at Springboro, Ind. The nearest railroad station is Delphi, 5 miles east of Springboro. A standard chain gage is located on the second span from the east bank, one panel length beyond the center of the span. The length of the chain from the end of the weight to the marker is 25.66 feet. The gage is read once each day by Lois Imler. Discharge measurements are made from the downstream side of the bridge, to which the gage is attached. The initial point for soundings is the face of the east abutment. The channel is straight for about 1,600 feet above and about 2,000 feet below the station. Its width at ordinary stages is 350 feet, broken by two piers, and at high water is 510 feet, broken by three piers. Both banks are high and can not overflow to any considerable extent. The bed of the stream is rocky and rough; the current is swift. The bench mark is the head of an anchor bolt in the east abutment; it is the outside anchor of the downstream truss. Its elevation above the zero of the gage is 22.25 feet.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of Tippecanoe River near Delphi, Ind., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
January 23	F. W. Hanna	448	2,404	4.10	8.48	9,863
March 2[a]	do	466	3,920	2.55	13.00	10,010
March 28	do	449	2,560	4.78	8.80	12,240
May 2	Hanna and Johnson	343	917	4.04	4.95	3,708
June 18	F. W. Hanna	253	328	2.12	2.98	694
July 23	Hanna and Johnson	238	292	1.83	2.92	534
August 22	F. W. Hanna	255	370	2.38	3.20	882
September 13	do	241	278	1.62	2.85	451
October 22	do	249	273	1.77	2.90	484
November 5	do	240	266	1.49	2.86	396

[a] Ice jam.

Mean daily gage height, in feet, of Tippecanoe River near Delphi, Ind., for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.[a]	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.[a]
1	.....	.....	14.60	9.55	6.59	4.25	3.49	2.85	2.93	3.10	2.83	2.83
2	.....	.....	13.44	9.43	5.07	4.21	3.37	2.82	2.90	3.07	2.82	2.82
3	.....	.....	13.21	8.49	4.80	3.87	3.21	2.80	2.87	3.05	2.84	2.80
4	.....	.....	12.90	8.34	5.60	3.74	3.09	2.81	2.86	3.00	2.84	2.80
5	.....	.....	12.37	8.21	5.12	3.65	3.17	2.81	2.84	2.95	2.85	2.91
6	4.10	8.25	12.25	8.03	4.96	3.61	3.22	2.77	2.85	2.91	2.85	2.96
7	.....	.....	12.80	7.95	4.72	3.40	3.75	2.75	2.83	2.90	2.84	2.97
8	3.60	.....	13.20	8.20	4.57	3.45	4.03	2.73	2.83	2.93	2.80	2.98
9	.....	.....	12.47	8.75	4.35	3.49	4.40	2.78	2.84	3.00	2.85	3.00
10	.....	.....	7.05	8.15	4.05	3.52	4.37	2.72	2.85	3.07	2.87	3.02
11	.....	.....	7.00	7.75	4.00	3.43	4.26	2.71	2.85	3.05	2.86	3.00
12	.....	.....	6.95	7.08	3.93	3.18	4.20	2.69	2.84	3.00	2.85	2.99
13	.....	7.85	6.90	5.53	3.84	3.17	4.17	2.74	2.81	3.00	2.86	2.98
14	.....	.....	7.00	4.98	3.89	3.13	3.98	2.73	3.00	2.98	2.84	.....
15	.....	.....	6.87	5.02	3.91	3.13	3.96	2.72	2.98	2.97	2.87	.....
16	3.85	.....	6.77	5.17	3.89	3.12	3.71	2.71	3.01	3.03	2.89	.....
17	.....	.....	7.00	5.17	3.85	3.54	3.55	2.78	3.05	3.00	2.88	3.04
18	.....	.....	7.20	5.14	4.01	3.27	3.47	2.80	3.21	2.97	2.86	.....
19	.....	.....	7.23	5.12	3.99	3.20	3.38	2.81	3.10	2.95	2.86	.....
20	4.75	8.20	7.10	5.09	3.95	3.16	3.30	2.90	3.05	2.92	2.85	.....
21	11.05	.....	7.15	4.98	3.90	3.10	3.21	3.05	3.00	2.90	2.83	.....
22	11.25	.....	7.77	4.91	3.81	3.09	3.00	3.35	2.98	2.98	2.80	.....
23	10.95	.....	8.10	4.67	3.70	3.07	2.95	3.42	2.97	2.95	2.85	3.05
24	.....	.....	8.54	4.47	3.64	3.06	2.91	3.40	2.95	2.94	.....	3.09
25	.....	.....	8.92	4.01	3.73	3.00	2.90	3.35	2.93	2.97	.....	3.12
26	.....	.....	11.20	5.80	3.72	2.96	2.90	3.28	3.10	2.95	.....	.....
27	15.00	8.20	9.41	7.03	3.71	3.00	2.99	3.18	3.15	2.92	.....	.....
28	.....	.....	7.94	6.70	3.70	3.83	2.98	2.98	3.23	2.81	.....	.....
29	.....	15.20	7.02	6.35	3.60	3.71	2.93	3.00	3.20	2.85	2.84	.....
30	7.25	.....	6.76	6.10	3.74	3.79	2.91	2.93	3.16	2.85	2.83	3.05
31	.....	.....	8.90	.....	4.20	.....	2.89	2.90	.....	2.84	.....	.....

[a] Frozen January 1 to March 9 and December 14 to 31.

Rating table for Tippecanoe River near Delphi, Ind., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet*
2.7	280	3.8	1,770	4.9	3,640	7.0	8,110
2.8	390	3.9	1,930	5.0	3,830	7.5	9,220
2.9	510	4.0	2,090	5.2	4,230	8.0	10,370
3.0	630	4.1	2,250	5.4	4,650	8.5	11,520
3.1	760	4.2	2,410	5.6	5,070	9.0	12,670
3.2	890	4.3	2,580	5.8	5,490	9.5	13,820
3.3	1,030	4.4	2,750	6.0	5,910	10.0	14,970
3.4	1,170	4.5	2,920	6.2	6,350	10.5	16,120
3.5	1,320	4.6	3,090	6.4	6,790	11.0	17,270
3.6	1,470	4.7	3,270	6.6	7,230	12.0	19,570
3.7	1,620	4.8	3,450	6.8	7,670	13.0	21,870

The above table is applicable only for open-channel conditions. It is based upon discharge measurements made during 1903 and 1904. It is well defined between gage heights 2.8 feet and 8.8 feet. The table has been extended beyond these limits. Above gage height 7.4 feet the rating curve is a tangent, the difference being 230 per tenth.

Estimated monthly discharge of Tippecanoe River near Delphi, Ind., for 1904.

[Drainage area, 1,890 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
March 10 to 31	17,730	7,560	9,633	5.10	4.17
April	13,940	2,090	7,210	3.81	4.25
May	7,230	1,470	2,492	1.32	1.52
June	2,495	582	1,199	.634	.707
July	2,750	498	1,247	.660	.761
August	1,200	269	534	.282	.325
September	932	402	601	.318	.355
October	760	402	585	.310	.357
November	498	390	446	.236	.264
December 1 to 13	656	390	543	.287	.139

WHITE RIVER (WEST BRANCH) AT INDIANAPOLIS, IND.

This station was established May 6, 1904, by E. Johnson, jr., assisted by F. W. Hanna. It is located in the central portion of the city on the bridge of the Cleveland, Cincinnati, Chicago, and St. Louis Railway. A standard chain gage is attached to the downstream side of the bridge, the scale being graduated to feet and tenths on the downstream side of the binding tie. The length of the chain from the end of the weight to the marker, which is the outside of the ring, is 37.10 feet. The gage is read twice each day by J. D. Burk. The chain and weight are kept at the water softening plant of the Kingan Packing Company, located 100 feet downstream from the right abutment of the bridge. Discharge measurements are made from the downstream side of the through Pratt truss bridge of three spans, to which the gage is attached. The initial point for soundings is the downstream inner face of the right abutment. The channel is straight for about 500 feet above and for 1,000 feet below the station. The current is direct, but sluggish in low stages. The right bank is moderately high and seldom overflows. The left bank is high, covered by buildings, and never overflows. All the water passes between the abutments of the bridge. The bed of the stream is composed of gravel and sand, and is fairly permanent. There are three channels at all stages. At low water the current is too sluggish to permit of very accurate measurement. Bench mark No. 1 is the south capstone of the ballast wall of the right abutment. Its elevation is 36.51 feet above the datum of the gage. Bench mark No. 2 is the downstream top edge of the fifth cross girder from the right abutment of the bridge. Its elevation is 36.54 feet above the datum of the gage.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of White River (West Branch) at Indianapolis, Ind., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
May 6	Johnson and Hanna	265	1,423	0.81	8.80	1,147
June 17	F. W. Hanna	256	1,324	.65	8.45	866
July 29	do	222	1,129	.34	7.53	380
August 23	do	233	1,210	.41	7.85	495
September 14	do	223	1,042	.23	7.20	240
October 21 [a]	do	68	150	1.43	7.30	216
November 4 [a]	do	68	131	1.49	7.20	195

[a] Measurement made from boat and cable 1 mile below station.

Mean daily gage height, in feet, of White River (West Branch) at Indianapolis, Ind., in 1904.

Day.	Mar.[a]	Apr.[a]	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	18.85	.....	8.90	8.30	7.50	7.30	7.40	7.20	7.10
2	.....	21.66	.....	9.50	8.45	7.45	7.30	7.10	7.20	7.10
3	.....	20.90	.....	9.20	8.35	7.40	7.30	7.30	7.20	7.10
4	.....	14.71	.....	9.10	8.25	7.40	7.20	7.30	7.20	7.10
5	.....	.....	.....	9.10	8.20	7.40	7.20	7.30	7.20	7.10
6	.....	.....	8.80	8.75	8.20	7.35	7.25	7.25	7.20	7.10
7	.....	.....	8.75	8.60	9.10	7.35	7.30	7.25	7.20	7.10
8	.....	.....	8.70	8.40	9.50	7.35	7.30	7.20	7.20	6.75
9	.....	.....	8.70	8.30	9.45	7.30	7.25	7.20	7.30	6.70
10	.....	.....	8.70	8.30	9.20	7.30	7.20	7.20	7.25	7.10
11	.....	.....	8.60	8.20	8.90	7.40	7.20	7.50	7.20	7.10
12	.....	.....	8.50	8.20	8.70	7.30	7.20	7.50	7.20	7.10
13	.....	.....	8.50	8.10	8.50	7.25	7.20	7.40	7.20	7.10
14	.....	.....	8.40	8.10	8.40	7.20	7.25	7.40	7.10	6.90
15	.....	.....	8.40	8.00	8.20	7.15	7.20	7.30	7.20	6.85
16	.....	.....	8.40	8.10	8.10	7.20	7.20	7.30	7.20	7.30
17	.....	.....	8.40	8.50	8.00	7.20	7.20	7.30	7.20	7.15
18	.....	.....	8.50	8.50	8.00	7.10	7.25	7.30	7.20	7.15
19	.....	.....	8.70	8.70	7.90	7.20	7.30	7.30	7.20	7.10
20	.....	.....	8.90	9.10	7.90	7.50	7.55	7.30	7.20	7.10
21	.....	.....	9.10	9.60	7.85	7.80	7.35	7.30	7.20	7.10
22	.....	.....	9.10	9.60	8.00	8.20	7.30	7.30	7.20	7.10
23	.....	.....	8.80	9.00	8.00	8.00	7.30	7.30	7.20	7.20
24	.....	.....	8.70	8.90	7.85	7.65	7.30	7.30	7.20	7.50
25	.....	.....	8.70	8.55	7.80	7.60	7.40	7.25	7.20	7.60
26	21.42	.....	8.60	8.45	7.70	7.40	7.70	7.25	7.20	7.70
27	24.74	.....	8.70	8.40	7.65	7.35	7.60	7.25	7.20	9.20
28	21.21	.....	8.70	8.30	7.60	7.30	7.60	7.20	7.10	9.70
29	13.79	.....	8.80	8.30	7.55	7.30	7.60	7.10	7.10	8.75
30	12.15	.....	8.80	8.30	7.50	7.25	7.60	7.15	7.10	8.45
31	13.26	.....	8.90	.....	7.50	7.30	.....	7.15	.....	8.50

[a] Readings March 26 to April 4 reduced from readings of Kingan gage.

Rating table for White River (West Branch) at Indianapolis, Ind., from May 6 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
7.0	184	7.6	380	8.2	700	8.8	1,150
7.1	211	7.7	425	8.3	770	8.9	1,240
7.2	240	7.8	475	8.4	840	9.0	1,330
7.3	271	7.9	525	8.5	910		
7.4	304	8.0	580	8.6	990		
7.5	340	8.1	640	8.7	1,070		

The above table is applicable only for open-channel conditions. It is based upon 7 discharge measurements made during 1904. It is well defined between gage heights 7.2 feet and 8.8 feet. The table has been extended beyond these limits.

Estimated monthly discharge of White River (West Branch) at Indianapolis, Ind., for 1904.

[Drainage area, 1,520 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
May 6–31	1,420	840	1,064	0.700	0.677
June	1,870	580	1,045	.688	.768
July	1,780	340	759	.499	.575
August	700	211	314	.207	.239
September	425	240	284	.187	.209
October	340	211	265	.174	.201
November	271	211	238	.157	.175
December	1,960	115	391	.257	.296

LOWER EEL RIVER NEAR CATARACT, IND.

This station was established August 6, 1903, by E. Johnson, jr., assisted by L. R. Stockman. It is located 6 miles from Cloverdale, Ind., and one-half mile northeast of Cataract, Ind. It is 300 feet above a dam below which there is a fall of 35 feet. The gage is a 3 by 6 inch oak timber, securely fastened to the west abutment on the downstream face. It is marked by brass-headed nails and reads from zero to 10 feet. The gage is read once each day by Joe Steiner. Discharge measurements are made from the upstream side of the single-span, covered highway bridge, which has a length between abutments of 128 feet. The initial point for soundings is the face of the left or west abutment at the top of the coping on the upstream side. Distances are marked by wire nails and painted figures on the guard rail on the upstream side of the bridge. The channel is straight for about 500 feet above and 300 feet below the bridge. The current varies from swift to rather sluggish. Both banks are high and rocky and will not overflow. The bed of the stream is a smooth rock ledge, nearly level between the bridge abutments.

Bench mark No. 1 is a wire nail in the root of a small elm tree in a stone wall on the north side of the road approaching the bridge on the west side of the river about 50 feet from the bridge. Its elevation above the zero of the gage is 12.60 feet. Bench mark No. 2 is a wire nail in the root of a large oak tree in the pasture on the west side of the river 300 feet from the bridge and 20 feet from the fence which bounds the south side of the road approaching the bridge. The elevation of this bench mark is 27.20 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

One measurement was made on May 4, 1904; gage height, 1.28 feet; discharge, 104 second-feet.

Mean daily gage height, in feet, of Eel (lower) River near Cataract, Ind., for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.60	2.40	3.50	4.80	2.00	1.40	1.40	0.90	1.10	1.40	0.80	[b]
2	1.60	2.40	3.60	4.90	2.10	1.30	1.30	.90	1.20	1.40	.80	[b]
3	1.50	2.40	3.70	4.80	2.10	1.30	1.30	.90	1.20	1.30	.70	[b]
4	1.50	2.40	3.70	4.80	2.20	1.30	1.30	.90	1.10	1.30	.70	[b]
5	1.50	2.40	3.60	4.60	2.20	1.20	1.20	.90	1.10	1.20	.70	[b]
6	1.50	2.60	2.70	3.60	2.20	1.20	1.20	.90	1.00	1.10	.80	[b]
7	1.50	4.00	2.90	3.00	2.20	1.30	1.20	.80	1.00	1.10	.90	[b]
8	1.50	4.00	2.90	2.50	2.10	1.40	1.20	.80	.90	1.10	1.00	[b]
9	1.50	4.00	2.60	2.20	2.10	1.40	1.20	.80	.80	1.20	1.00	[b]
10	1.50	4.00	2.60	2.10	2.10	1.40	1.10	.80	.60	1.20	1.00	[b]
11	1.50	3.90	2.70	2.10	2.20	1.30	1.10	.80	.70	1.30	1.00	[b]
12	1.50	3.70	2.60	2.10	2.30	1.30	1.10	.80	.70	1.20	1.00	[b]
13	1.50	3.40	2.30	2.00	2.30	1.40	1.10	.80	.70	1.10	1.10	[b]
14	1.50	3.20	2.25	2.00	2.20	1.40	1.10	.90	.80	1.00	1.10	[b]
15	1.50	3.20	2.30	2.00	2.20	1.40	1.10	.90	.90	1.00	1.10	[b]
16	1.50	3.10	2.40	2.00	2.20	1.40	1.10	.90	1.00	1.00	1.00	[b]
17	1.60	3.00	2.50	2.10	2.10	1.40	1.05	.90	1.00	1.00	1.00	[b]
18	1.70	2.90	2.60	2.10	2.10	1.40	1.05	.90	1.00	1.10	1.10	[b]
19	1.90	2.90	2.70	2.00	2.10	1.40	1.05	.90	1.10	1.10	1.00	[b]
20	2.50	2.90	2.80	2.00	2.00	1.50	1.10	1.00	1.10	1.10	1.00	[b]
21	2.70	2.90	2.90	2.00	2.00	1.50	1.00	1.00	1.20	1.10	1.00	[b]
22	4.10	2.90	3.00	2.00	2.00	1.50	1.00	1.00	1.10	1.00	1.00	0.50
23	4.10	3.00	3.40	2.00	2.00	1.50	1.00	1.00	1.00	1.00	1.00	.80
24	4.00	3.00	3.50	2.20	2.00	1.50	1.00	1.10	1.00	1.00	1.00	1.30
25	3.90	3.00	4.70	2.20	1.80	1.60	1.00	1.20	1.20	1.10	1.00	1.40
26	3.60	3.00	6.60	2.10	1.80	1.60	.90	1.20	1.40	1.00	1.00	1.70
27	3.40	3.00	6.60	2.10	1.70	1.50	.90	1.20	1.45	1.00	.80	2.00
28	3.00	3.20	6.30	2.10	1.60	1.50	.90	1.10	1.55	1.00	.70	2.30
29	2.70	3.40	5.20	2.10	1.50	1.40	.90	1.10	1.50	.90	.50	2.70
30	2.60	.....	4.00	2.00	1.50	1.40	.90	1.10	1.40	.90	.40	3.00
31	2.40	.....	3.90	.....	1.40	.....	.90	1.00	.....	.90	.....	3.30

[a] Ice conditions January and February. [b] Below gage.

NOTE.—The zero of the gage is 0.96 feet below the crest of the dam; therefore when the gage is below 0.96 all the water flows through a small flume.

WHITE RIVER (EAST BRANCH) AT SHOALS, IND.

This station was established June 25, 1903, by A. C. Lootz. It is located at the highway bridge, in the village of Shoals, Ind., 400 feet above the Baltimore and Ohio Southwestern Railroad bridge. There are rapids just below this station and also about 5½ miles below. The gage is read once each day by O. H. Greist. A standard chain gage is fastened to the railing and metal posts of the downstream side of the first span on the left end of the highway bridge. The length of the chain from the end of the weight to the marker is 46.41 feet. Discharge measurements are made from the 3-span highway bridge to which the gage is attached. The initial point for soundings is the face of the left abutment. The channel is straight above and below the station and the current is swift. The right bank is a high rocky road embankment and never overflows; the left bank is a steep rocky bluff and does not overflow. The bed of the stream is rocky, and the channel is divided into three parts by the bridge piers. Bench mark No. 1 is the stone cap on the downstream end of the first pier from the left bank. Its elevation is 100 feet above gage datum.

The observations at this station during 1904 have been made under the direction of E. Johnson, jr., district hydrographer.

Discharge measurements of White River (East Branch) at Shoals, Ind., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Sq. feet.*	*Ft. per. sec.*	*Feet.*	*Second-ft.*
June 22 [a]	A. C. Lootz					2,000
August 4	L. R. Stockman	344	1,083	3.13	65.07	3,392
September 24	do	286	408	1.25	63.40	511
1904.						
January 24	F. W. Hanna		4,105	4.61	73.47	19,010
March 5	do	375	2,321	4.99	68.64	11,590
March 30	do	427	13,410	6.00	95.20	79,820
May 5	F. W. Hanna and Johnson.	356	1,124	3.72	65.43	4,180
June 16	F. W. Hanna	349	789	2.30	64.53	1,812
July 28	do	307	515	1.60	63.88	823
August 24	do	295	379	1.28	63.32	484
September 15	do	295	373	1.06	63.24	397
October 20	do	295	371	1.07	63.23	396
November 3	do	288	324	.99	63.17	320

[a] Float measurement.

Mean daily gage height, in feet, of White River (East Branch) at Shoals, Ind., for 1904.

Day.	Jan.[a]	Feb.[a]	Mar.[a]	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.[b]
1	64.60	66.20	67.60	91.00	67.00	64.80	65.30	63.80	63.30	63.50	63.20	63.20
2	64.50	65.50	68.10	88.80	66.50	65.60	65.10	63.70	63.30	63.50	63.20	63.20
3	64.30	65.20	68.20	87.20	65.90	66.00	65.00	63.70	63.30	63.50	63.20	63.20
4	64.20	64.90	68.70	85.60	65.60	66.00	64.80	63.70	63.30	63.40	63.20	63.20
5	64.10	64.80	68.60	84.40	65.40	65.60	64.70	63.70	63.30	63.40	63.20	63.20
6	64.10	68.50	69.10	83.40	65.30	65.40	64.50	63.70	63.20	63.30	63.20	63.20
7	64.10	71.50	72.30	80.20	65.10	65.00	64.40	63.70	63.20	63.30	63.20	63.20
8	64.00	72.80	72.90	73.20	65.00	64.90	64.30	63.70	63.20	63.30	63.20	63.20
9	64.00	74.30	71.50	68.40	64.90	64.70	64.30	63.70	63.20	63.30	63.20	63.20
10	64.00	76.10	70.30	67.70	64.80	64.60	64.30	63.60	63.30	63.30	63.20	63.20
11	64.00	77.00	70.50	67.50	64.70	64.50	64.40	63.60	63.30	63.30	63.20	63.20
12	64.00	76.00	69.80	67.30	64.70	64.40	64.50	63.60	63.30	63.30	63.20	63.20
13	64.00	72.50	69.10	67.00	64.70	64.40	64.50	63.50	63.30	63.30	63.20	63.20
14	64.00	68.50	68.90	66.80	64.60	64.30	64.50	63.50	63.30	63.30	63.20	63.20
15	64.00	66.50	68.70	66.50	64.60	64.40	64.40	63.50	63.30	63.30	63.20	63.00
16	64.00	66.00	68.00	66.20	64.50	64.30	64.50	63.50	63.20	63.30	63.20	63.00
17	64.00	65.90	67.60	66.00	64.50	64.50	64.30	63.50	63.20	63.30	63.20	63.10
18	64.00	65.60	67.50	65.80	66.50	64.60	64.20	63.50	63.40	63.30	63.20	63.10
19	64.10	65.40	67.60	65.60	66.50	64.70	64.20	63.50	63.70	63.30	63.20	63.20
20	64.10	65.20	67.70	65.40	64.50	64.90	64.20	63.50	63.60	63.30	63.20	63.20
21	64.60	65.10	67.70	65.30	64.50	64.90	64.20	63.60	63.50	63.30	63.20	63.20
22	69.40	67.30	68.00	65.20	64.50	64.90	64.20	63.60	63.50	63.20	63.20	63.20
23	78.30	68.30	74.40	65.10	64.60	64.80	64.20	63.60	63.40	63.20	63.20	63.20
24	73.50	69.60	75.20	65.10	64.70	64.80	64.10	63.50	63.40	63.20	63.20	63.30
25	74.20	70.90	78.40	65.20	64.60	64.80	64.10	63.40	63.40	63.20	63.20	63.40
26	74.50	70.60	87.10	66.50	64.60	64.80	64.00	63.40	63.70	63.20	63.20	63.90
27	74.80	69.40	87.70	67.50	64.80	64.80	64.00	63.30	63.80	63.20	63.20	64.50
28	75.00	68.00	92.80	68.60	64.60	65.20	63.90	63.30	63.80	63.20	63.20	65.20
29	72.20	67.30	95.00	68.40	64.60	64.80	63.90	63.30	63.70	63.20	63.20	66.00
30	67.80	.....	94.90	67.80	64.60	65.40	63.80	63.30	63.50	63.20	63.20	66.30
31	66.50	.....	93.40	.....	64.70	.....	63.80	63.30	.....	63.20	.....	66.00

[a] Ice conditions January, February, and March; uncertain. [b] Frozen December 15 to 31.

Rating table for White River (East Branch) at Shoals, Ind., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
63.0	215	64.7	2,000	67.4	8,110	76.0	30,030
63.1	286	64.8	2,150	67.6	8,610	77.0	32,630
63.2	360	64.9	2,310	67.8	9,110	80.0	40,430
63.3	440	65.0	2,470	68.0	9,610	83.0	48,230
63.4	520	65.1	2,640	68.5	10,860	84.0	50,830
63.5	605	65.2	2,820	69.0	12,110	85.0	53,430
63.6	695	65.3	3,010	69.5	13,360	87.0	58,630
63.7	790	65.4	3,210	70.0	14,610	88.0	61,230
63.8	890	65.6	3,640	70.5	15,860	90.0	66,430
63.9	990	65.8	4,110	71.0	17,110	91.0	69,030
64.0	1,100	66.0	4,610	71.5	18,360	92.0	71,630
64.1	1,210	66.2	5,110	72.0	19,630	93.0	74,230
64.2	1,330	66.4	5,610	72.5	20,930	94.0	76,830
64.3	1,450	66.6	6,110	73.0	22,230	95.0	79,430
64.4	1,580	66.8	6,610	73.5	23,530		
64.5	1,710	67.0	7,110	74.0	24,830		
64.6	1,850	67.2	7,610	75.0	27,430		

The above table is applicable only for open-channel conditions. It is based upon 13 discharge measurements made during 1903 and 1904. It is well defined between gage heights 63.2 feet and 65.4 feet. Above gage height 72 feet the rating curve is a tangent the difference being 260 per tenth. Two flood measurements above 65.4 feet gage height define the tangent. The table has been extended beyond these limits.

Estimated monthly discharge of White River (East Branch) at Shoals, Ind., for 1904.

[Drainage area, 4,900 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January [a]	27,430	1,100	7,320	1.49	1.72
February [a]	32,630	2,150	11,710	2.39	2.58
March [a]	79,430	8,360	25,310	5.17	5.96
April	69,330	2,640	1,822	.372	.415
May	7,110	1,710	2,709	.553	.638
June	4,610	1,450	2,375	.485	.541
July	3,010	890	1,539	.314	.362
August	890	440	647	.132	.152
September	890	360	525	.107	.119
October	605	360	435	.089	.103
November	360	360	360	.073	.081
December [a]	5,360	215	932	.190	.219
The year	79,430	215	4,640	.947	12.89

[a] January, February, March, and December estimates computed as if open channel.

CUMBERLAND RIVER DRAINAGE BASIN.

Cumberland River rises in the eastern part of Kentucky and flows west till it meets the South Fork, which rises in northern Tennessee and flows northward. After this junction the Cumberland turns toward the southwest into Tennessee, and, after flowing through the north-central part, again enters Kentucky in Trigg County, flows across the State, and enters Ohio River at Smithland, about 15 miles above the mouth of Tennessee River. The gaging station on this river is located at Nashville, Tenn.

CUMBERLAND RIVER AT NASHVILLE, TENN.

The gage, which belongs to the United States Engineer Corps, is at the foot of Broad street. It is in three sections, two of which are upright and one inclined. The lowest section, extending from −0.2 foot to +46 feet, is on the slope of the bank and consists of timbers embedded in the ground, bearing an iron strap, into which the markings are cut. The section extending from gage height 46 to 53 feet is fastened to a small building at the top of the bank, and consists of a timber painted white with black markings. The top section of the gage, extending from 52 feet to 55.3 feet, is on the corner of Temperance Hall, painted on the stones in white with black markings. In addition there is a vertical section reading from −1.2 feet to +2 feet. Discharge measurements are made from the upstream side of Woodlawn Street Bridge, which has four spans having a total length of 656 feet. The floor of the bridge is on a slope, the lower or right bank end being about 100 feet above low water. The initial point for soundings is the end of the iron hand rail on the upstream side of the bridge at the left bank. The channel is nearly straight for 2,000 feet above and for 1,500 feet below the station. The right bank is high, but overflows at high stages. It is occupied by lumber yards and sawmills. The left bank is high, rocky, and is not subject to overflow. The bed of the stream is composed of rock and is permanent. There is one channel broken by one pier at ordinary and by three piers at high water.

During October, 1904, a lock and dam were completed about 2½ miles below the gage, which at low water raises the water surface at the gage about 5½ feet and causes the low-water velocity to become rather slow for good measurements. The datum of the gage corresponds to elevation 110.3 feet of the city levels. A cross, cut on the upper face of the corner stone in the southeast corner of Temperance Hall, on Broad street, near Front street, is 52 feet above the zero of the gage, and 366.6 feet above mean sea level. The highest observed water was 55.3 feet on January 22, 1882. The lowest occurred on October 15 and 16, 1878, at a gage height of −0.4 foot. The danger line is at 40 feet.

Records have been kept for a number of years by the United States Weather Bureau, from which readings previous to those here published may be obtained.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Cumberland River at Nashville, Tenn., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
May 18	J. M. Giles	344	4,789	2.87	8.25	13,730
May 19	do	344	5,034	2.79	8.35	14,030
May 20	do	344	5,031	2.59	8.13	13,030
August 19	do	313	2,991	.88	2.26	2,630
August 19	do	313	3,000	.88	2.30	2,648
August 20	do	313	2,924	.83	2.22	2,428
October 22	do	328	4,239	.36	[a]6.60	1,534

[a] Rise in gage height caused by new dam 2¼ miles below station=5.6.

Mean daily gage height, in feet, of Cumberland River at Nashville, Tenn., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	11.50	8.60	10.10	31.90	9.50	6.90	6.20	2.70	2.30	1.00	6.60	6.80
2	9.40	7.60	9.80	24.10	9.80	8.40	5.40	2.70	2.10	1.10	6.60	6.90
3	9.40	6.90	9.70	19.20	9.80	11.70	4.80	3.00	1.90	1.20	6.70	6.90
4	9.70	6.30	9.40	15.40	10.50	14.00	4.80	2.90	3.20	1.10	6.70	6.90
5	9.40	5.80	9.10	13.20	11.40	15.20	4.90	2.70	2.10	1.00	6.80	7.00
6	10.50	5.40	8.70	11.70	12.40	14.40	4.70	2.70	1.80	1.00	6.70	7.00
7	11.00	5.00	9.80	10.40	11.90	13.10	4.60	2.70	1.70	1.00	6.80	7.40
8	10.40	4.90	14.30	9.60	10.90	14.80	4.00	2.60	1.60	1.00	6.80	7.40
9	9.00	4.90	15.70	8.80	10.70	14.70	4.20	2.50	1.70	1.20	6.90	7.50
10	7.60	4.90	17.80	8.50	10.20	14.00	4.50	2.50	1.60	1.00	6.90	8.30
11	6.70	5.70	21.20	8.40	10.00	11.80	4.80	2.40	1.50	[a]1.50	6.90	8.10
12	6.10	7.20	22.50	8.60	10.20	10.00	4.60	2.50	1.40	2.80	6.90	8.90
13	6.00	8.00	20.70	8.30	10.00	8.70	4.70	2.60	1.40	3.70	6.90	9.00
14	6.00	7.60	18.30	7.80	10.30	7.50	4.10	2.50	1.40	4.60	6.80	8.70
15	7.20	7.20	16.00	7.40	10.00	6.40	3.90	2.50	1.50	5.30	6.80	8.50
16	7.00	7.00	14.40	7.10	9.10	5.50	3.70	2.40	1.40	6.00	6.80	8.30
17	7.10	6.00	14.60	6.80	8.40	4.90	3.60	2.30	1.30	6.50	6.80	8.30
18	9.00	5.60	14.30	6.80	8.30	4.40	3.30	2.30	1.20	6.60	6.90	8.30
19	9.70	5.30	13.60	6.40	8.30	4.30	3.80	2.20	1.20	6.60	6.90	8.30
20	10.00	5.10	13.00	6.20	8.10	3.60	3.70	2.20	1.70	6.60	6.90	8.10
21	11.40	5.00	12.40	6.10	7.50	4.10	3.50	2.20	1.20	6.60	6.90	8.00
22	14.30	5.10	18.10	6.00	6.90	3.70	3.50	2.20	1.30	6.60	6.90	7.80
23	16.80	5.30	21.40	6.00	6.30	3.40	3.70	2.30	1.20	6.60	6.90	7.70
24	16.60	5.30	26.10	6.00	6.00	3.50	3.30	2.30	1.10	6.60	6.90	7.80
25	18.00	5.60	27.90	6.40	5.70	3.40	3.00	2.80	1.00	6.60	6.90	8.30
26	20.00	6.40	31.30	6.70	5.40	3.30	3.00	4.40	1.00	6.60	6.90	8.90
27	20.50	7.90	37.30	6.90	5.00	3.20	3.00	3.90	1.10	6.60	6.90	11.40
28	18.70	9.60	37.20	7.30	4.60	4.20	3.00	3.30	1.10	6.60	6.80	18.40
29	15.60	10.10	36.90	8.00	4.20	5.50	2.80	2.90	1.10	6.60	6.80	16.70
30	12.60	.....	36.20	8.70	4.20	5.40	2.80	2.60	1.00	6.60	6.80	18.50
31	10.00	.....	33.90	.....	5.00	.....	2.70	2.50	.....	6.50	.....	18.80

[a] Dam at lock 2¼ miles below put into operation, raising water level at gage about 5.6 feet above low-water stage.

TENNESSEE RIVER DRAINAGE BASIN.

Tennessee River is formed by the junction of the French Broad and the Holston about 4 miles above Knoxville, Tenn. It flows southwest, crossing into Alabama about 40 miles below Chattanooga, Tenn., and, after crossing the northern part of Alabama, again enters Tennessee in Harding County. It then flows north, crossing Tennessee and Kentucky, and enters Ohio River at Paducah, about 40 miles above Cairo. Its principal tributary on the north is Clinch River, which enters it near Kingston, Roan County, Tenn. The principal tributaries on the south are Hiwassee and Little Tennessee rivers. Hiwassee rises in the northern part of Georgia and flows into the Tennessee about 30 miles above Chattanooga. Its principal tributaries are the Okoee and the Nottely. Little Tennessee River rises in the northeastern corner of Georgia, flows across the southwestern part of North Carolina, and enters the Tennessee near Loudon, Tenn. Its principal tributary is the Tuckasegee. French Broad River rises in the western part of North Carolina. Its principal tributaries are the Pigeon and the Nolichucky. Holston River rises in the western part of Virginia. Its principal tributary is Watauga River, into which stream Roan Creek enters.

FRENCH BROAD RIVER AT HORSESHOE, N. C.

This station was established October 4, 1904, by B. S. Drane. It is located at the steel highway bridge at Horseshoe, N. C. A plain staff gage, graduated to feet and tenths, is attached vertically to a 1½ by 4 inch oak timber which is driven into the bed of the stream to a firm foundation and nailed to an overhanging birch on the right bank, 25 feet below the bridge. The gage is read once each day by Charles Duncan. Discharge measurements are made from the downstream side of the single-span, five-panel truss bridge mounted on stone abutments. The approach on each side is over an earth embankment. On the left bank a flood channel 81 feet wide is opened through the embankment 140 feet from the end of the bridge. The initial point for soundings is on the downstream hand rail over the inner edge of the capstone of the left abutment. The channel is straight for about 2,000 feet above and 1,500 feet below the station. The current is of fair velocity at all stages except at the lowest when it inclines to be sluggish along the right bank. The right bank is of earth, wooded, and about 15 feet high. The left bank is similar but is cleared. The earth embankments on either side to the higher ground are of such a height that all the water passes beneath the bridge and the overflow channel at all stages. There is but one channel at low and ordinary stages. The bed of the stream is composed of sand and a few rocks. It is smooth and permanent. Bench mark No. 1 is the upper surface

of the downstream end of the first floor beam from the left bank, 15 feet from the initial point for soundings. Its elevation is 20.48 feet above the zero of the gage. Bench mark No. 2 is the center of the head of a wire nail driven into the downstream face of a large birch tree on the right bank, about 20 feet above the bridge. Its elevation is 12.40 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of French Broad River at Horseshoe, N. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
July 18	B. S. Drane	82	241	1.64	0.86	396
August 18	do	82	285	1.86	1.51	529
October 3	do	81	192	1.50	.51	290
December 7	do	81	318	1.84	1.91	584

Mean daily gage height, in feet, of French Broad River at Horseshoe, N. C., for 1904.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1	0.50	0.35	0.60	12	0.40	0.50	1.00	23	0.30	0.65	0.75
2	.50	.35	.55	13	.40	1.50	.90	24	.30	.65	.75
3	.50	.45	.65	14	.35	2.00	.80	25	.30	.55	.90
4	.50	2.45	.75	15	.35	1.10	.80	26	.35	.55	1.00
5	.50	2.10	.75	16	.35	.90	.85	27	.35	.55	1.55
6	.50	1.75	4.60	17	.30	.80	.85	28	.35	.55	6.00
7	.50	1.00	2.20	18	.30	.75	.95	29	.35	.50	3.30
8	.55	.75	1.50	19	.30	.70	.85	30	.35	.50	2.15
9	.45	.60	1.30	20	.30	.65	.80	31	.35	.....	1.80
10	.45	.60	1.10	21	.30	.60	.80				
11	.40	.55	1.10	22	.30	.60	.75				

FRENCH BROAD RIVER AT BINGHAM SCHOOL BRIDGE, NEAR ASHEVILLE, N. C.

This station was established in September, 1895, by C. C. Babb. It is located at Bingham School Bridge crossing French Broad River at Riverside Park, about 3 miles west of Asheville, N. C. It was maintained as a regular station from 1895 to the close of 1901. It is now maintained as a bench-mark station. Discharge measurements are made from the upstream side of the three-span bridge. The initial point for soundings is the right end of the iron bridge on the upstream side. The channel is straight for about 700 feet above and below the station. The current is swift. Both banks are high, wooded, and not liable to overflow. The bed of the stream is composed of bowlders, very rough,

and permanent. There is but one channel at all stages, broken by two piers at ordinary stages and four piers at high stages. Since the regular station was discontinued a large waterpower development has been installed about six miles below, and it is possible that the rating of the station has been changed and the flow affected. Bench mark No. 1 is the upper edge of the steel plate riveted to the bridge post, over the second floor beam, from the right bank, on the upstream side of the bridge. Its elevation is 20 feet above gage datum. Bench mark No. 2 is the center of the head of a small nail driven into the limb on the downstream side of a large sycamore tree on the right bank, just above the bridge, along which a platform runs out over the water. Its elevation is 11.71 feet above gage datum.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of French Broad River at Bingham School Bridge, near Asheville, N. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
May 21	B. S. Drane	279	564	2.08	2.72	1,172
May 23	do	279	565	2.01	2.64	1,135
July 20	do	268	414	1.52	2.16	62[illegible]

FRENCH BROAD RIVER AT SMITH BRIDGE, NEAR ASHEVILLE, N. C.

This station was established May 21, 1904, as a bench-mark station. It is located about 1 mile below the Southern Railway depot at Asheville, N. C., and just down the hill from the terminal of the Patton avenue line of the Asheville Street Railway Company. The Southern Railway bridge is about 1,500 feet below and the Bingham School bridge about a mile below the station. A plain staff gage, graduated to feet and tenths, the property of the United States Weather Bureau, is bolted vertically to the southwest corner of the second stone pier from the left bank. A short section, reading from 0.00 downward, is set just downstream from the main section. Discharge measurements are made from the downstream side of the four-span bridge to which the gage is attached. The initial point for soundings is the left end of the downstream hand rail. The channel is straight for about 1,500 feet above and 800 feet below the station. The current has a good velocity. Both banks are clean, and will not overflow beyond the bridge and its approaches. The bed of the stream is composed of sand and silt, with a few scattered bowlders. There is but one channel at all stages, broken by three piers at ordinary stages and five piers at high-water stages. The operations of a waterpower development about 7 miles below will probably affect the flow at this point.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of French Broad River at Smith Bridge, near Asheville, N. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
May 21	B. S. Drane	345	843	1.31	—0.24	1,107
July 20	do	339	668	1.06	— .68	707
August 13	do	350	898	1.92	.09	1,725
October 1	do	328	487	1.04	— .91	506
December 10	do	330	656	1.08	— .68	707

FRENCH BROAD RIVER AT OLDTOWN, NEAR NEWPORT, TENN.

This was originally one of the temporary stations established in connection with the general hydrographic study of the southern Appalachian region.

The original gage put in at this station was carried away with the old bridge by flood early in the spring of 1902.

A wire gage was established on the new bridge October 27, 1902, by B. S. Drane. The wire gage was replaced April 29, 1903, by a standard chain gage, with inclosed scale, with its zero 133 feet from initial point for soundings. This gage was made to read the same as the one which it replaced. The length of the chain from the end of the weight to the marker is 28 feet. Discharge measurements are made from the downstream side of the steel highway bridge, in four spans, to which the gage is attached. The initial point for soundings is the end of the guard rail at the left end of the bridge, on the downstream side. The channel is straight for about 600 feet above and below the station. The velocity is moderately swift, well distributed, and can be measured at all stages. Both banks are high and wooded, and all water passes beneath the bridge at all stages. The section is smooth and regular, and the bed is of gravel and sand, not subject to much change.

Bench mark No. 1 is a point marked in white paint on the sharp, rectangular corner of the angle iron connection between the floor beam and the first post on the downstream side in the second span from the left end of the bridge. This point is toward the right bank and is 25.84 feet above gage datum. Bench mark No. 2 is the top of the copper bolt set in a bowlder projecting from the hillside on the left bank 175 feet downstream from the center line of the bridge, 8 feet from the center of the road, and about 4 feet above ground. This rock is the first smooth-faced ledge of limestone outcropping close to the road. The face next the road is nearly vertical for a length of 4 feet. The elevation of the bench mark is 29.52 feet above gage datum.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer:

Discharge measurements of French Broad River at Oldtown, near Newport, Tenn., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
February 23	B. S. Drane	453	2,155	2.59	2.92	5,568
February 23	do	453	2,136	2.51	2.87	5,358
March 29	do	450	1,928	1.97	2.34	3,804
April 27	M. R. Hall	448	1,925	1.57	2.12	3,025
July 8	J. M. Giles	334	1,371	.76	1.30	1,045
August 20	B. S. Drane	463	1,492	.92	1.50	1,380
October 15	do	442	1,267	.40	.98	508

Mean daily gage height, in feet, of French Broad River at Oldtown, near Newport, Tenn., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.30	1.50	1.90	2.00	2.00	2.30	1.95	1.40	1.45	1.10	0.95	1.25
2	1.30	1.50	2.00	1.90	1.80	2.40	1.70	1.70	1.40	1.10	1.00	1.30
3	1.30	1.40	1.90	1.80	2.00	2.00	1.60	1.60	1.80	1.05	1.05	1.30
4	1.30	1.50	1.90	1.80	1.85	1.80	1.50	1.50	1.90	1.00	1.10	1.25
5	1.20	1.50	1.90	1.75	1.90	1.70	1.40	1.65	1.80	1.00	1.50	1.45
6	1.20	1.40	2.00	1.70	1.80	1.60	1.45	1.60	1.70	1.00	1.70	1.95
7	1.20	1.60	2.90	1.75	1.85	1.70	1.40	1.70	1.45	1.00	1.40	2.10
8	1.30	2.10	4.50	1.90	2.00	1.90	1.30	1.80	1.40	1.00	1.30	1.70
9	1.40	2.10	3.70	2.00	3.35	1.85	1.70	1.80	1.35	1.00	1.20	1.50
10	1.30	1.80	2.70	2.00	2.80	1.65	1.60	1.85	1.40	1.00	1.10	1.35
11	1.30	1.70	2.55	2.00	2.40	1.70	1.50	1.90	1.35	.95	1.00	1.30
12	1.40	1.60	2.30	1.90	2.20	1.65	1.40	2.00	1.40	1.00	1.10	1.45
13	1.70	1.50	2.15	1.90	2.00	1.60	1.30	1.90	1.40	1.00	1.20	1.40
14	1.60	1.40	2.10	1.80	1.95	1.50	1.30	1.70	1.35	.95	1.45	1.35
15	1.60	1.60	2.20	1.80	1.90	1.45	1.20	1.60	1.30	1.00	1.45	1.35
16	1.50	1.50	2.00	1.80	1.80	1.45	1.15	1.70	1.25	.95	1.40	1.30
17	2.00	1.50	1.90	1.80	1.75	1.40	1.15	1.55	1.20	.95	1.35	1.30
18	2.10	1.50	1.90	1.80	1.70	1.40	1.15	1.55	1.20	.90	1.30	1.25
19	2.10	1.40	1.95	1.70	1.70	1.85	1.20	1.50	1.15	.95	1.30	1.20
20	1.90	1.50	1.90	1.70	1.70	1.75	1.20	1.50	1.20	.95	1.25	1.25
21	1.90	1.60	2.00	1.75	1.65	1.70	1.40	1.50	1.15	1.00	1.25	1.30
22	2.00	1.80	2.20	1.80	1.60	1.75	1.30	1.50	1.20	.95	1.25	1.25
23	2.10	2.90	4.20	1.70	1.55	1.65	1.40	1.55	1.15	1.05	1.40	1.25
24	2.50	2.30	3.70	1.75	1.60	1.55	1.55	1.95	1.15	.95	1.30	1.25
25	1.90	2.00	3.10	1.70	1.65	1.45	1.85	1.70	1.15	1.00	1.25	1.35
26	1.80	1.90	2.80	1.75	1.60	1.50	1.50	1.75	1.10	1.00	1.25	1.35
27	1.60	2.20	2.75	2.15	1.60	1.60	1.50	1.70	1.20	1.00	1.10	1.40
28	1.60	2.20	2.60	2.30	1.55	1.70	1.45	2.00	1.10	.95	1.00	1.30
29	1.50	2.00	2.30	2.20	1.50	1.90	1.40	1.95	1.15	1.00	1.10	2.25
30	1.40	.....	2.20	2.10	1.50	1.90	1.30	1.60	1.15	1.00	1.20	1.80
31	1.70	.....	2.10	.....	1.80	.....	1.30	1.50	.....	1.00	.....	1.70

Rating table for French Broad River at Oldtown, near Newport, Tenn., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.9	400	1.9	2,410	2.8	5,140	3.7	8,805
1.0	535	2.0	2,680	2.9	5,500	3.8	9,245
1.1	685	2.1	2,955	3.0	5,875	3.9	9,690
1.2	850	2.2	3,235	3.1	6,260	4.0	10,140
1.3	1,030	2.3	3,525	3.2	6,660	4.1	10,590
1.4	1,225	2.4	3,825	3.3	7,075	4.2	11,050
1.5	1,435	2.5	4,135	3.4	7,500	4.3	11,510
1.6	1,660	2.6	4,455	3.5	7,930	4.4	11,980
1.7	1,900	2.7	4,790	3.6	8,365	4.5	12,450
1.8	2,150						

The above table is applicable only for open-channel conditions. It is based upon 7 discharge measurements made during 1904, and one measurement made during 1903 to determine the upper part of the curve. It is well defined between gage heights 1 foot and 3 feet.

Estimated monthly discharge of French Broad River at Oldtown, near Newport, Tenn., for 1904.

[Drainage area, 1,737 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	4,135	850	1,758	1.01	1.16
February	5,500	1,225	2,063	1.19	1.28
March	12,450	2,410	4,271	2.46	2.84
April	3,525	1,900	2,333	1.34	1.50
May	7,288	1,435	2,407	1.39	1.60
June	3,825	1,225	1,957	1.13	1.26
July	2,545	768	1,299	.748	.862
August	2,680	1,225	1,877	1.08	1.24
September	2,410	685	1,125	.648	.723
October	685	400	526	.303	.349
November	1,900	468	943	.543	.606
December	3,380	850	1,375	.792	.913
The year	12,450	400	1,828	1.05	14.33

SWANNANOA RIVER AT BILTMORE, N. C.

This station was established as a bench-mark station May 21, 1904, by B. S. Drane. It is located at the Biltmore, N. C., terminal of the Asheville-Biltmore electric railway line, about three-fourths mile above the mouth of Swannanoa River. Discharge measurements are made from the upstream side of a single-span highway bridge. The initial point for soundings is the right end of the upstream hand rail of the bridge. The channel is straight for about 1,000 feet above and curved for 300 feet below the station. The current is sluggish above and somewhat swifter below the bridge. Both banks are high and not subject to overflow. The bed of the stream is composed of sand. There is but one channel at all stages. Bench mark No. 1 is the center of the center-pin bearing at the upstream end of the second floor beam from the right bank. Its elevation is 16 feet above the datum of the gage. Bench mark No. 2 is the center of the head of a small wire nail driven into a triangular-shaped blaze in the downstream side of a birch tree on the right bank, about 25 feet above the bridge. Its elevation is 5.74 feet above the datum of the gage.

Discharge measurements of Swannanoa River at Biltmore, N. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
May 21	B. S. Drane	73	165	0.86	1.12	143
July 20	do	72	107	.35	.71	38
August 16	do	74	134	.75	.97	101

TENNESSEE RIVER NEAR KNOXVILLE, TENN.

This station was originally established by the United States Weather Bureau at the old county highway bridge, which has been torn down and replaced by a new bridge. Instead of placing the gage at the new bridge, it was decided to move it down the river in order to get below some shoals and wing dams which have been put in for boating. A temporary gage was put in at the Knoxville and Augusta Railroad bridge, a half mile below the highway bridge, and was used during the greater part of the year 1899. In the latter part of that year a new permanent gage was established, and readings from it began on November 1, 1899. The new gage is on the right bank of the river, just below the mouth of West Knoxville Bayou, and about 1,000 feet below the temporary gage at the Knoxville and Augusta Railroad bridge. The gage, which is graduated to feet and tenths, is in two sections—the first, a sloping section, made of a 2 by 4 inch pine tim-

ber spiked on top of an 8 by 8 inch oak sill well bolted to piles and embedded in crushed stone, reading from −2 to +12 feet; the second, a vertical section, attached to one of the bents of the railroad trestle across West Knoxville Bayou, about 50 feet from the bank of the river and from the sloping gage, reading from 12 to 36.5 feet. The gage is fastened to the upstream post of the bent, facing away from the river. The zero of the gage is 804.3 feet above sea level. The gage was located for the United States Weather Bureau by the United States Engineer Corps. Daily records are kept by the United States Weather Bureau and are furnished to the Geological Survey. Until recently discharge measurements have been made from the Cherokee Bridge, about 2½ miles downstream from the Gay street or county bridge, at which measurements are now made, and which is one-half mile above the Knoxville and Augusta Railroad bridge. The Gay Street Bridge has seven spans, with a total length of 1,570 feet. The floor of the bridge is about 100 feet above low water. The initial point for soundings is the end of the bridge on the right bank, downstream side. The channel is straight for one-half mile above and for 1,000 feet below the station. The right bank will overflow for about 400 feet and the left bank for 200 feet, beyond which points a steep high bluff begins on both sides of the river. The bed is of rocks and gravel, and is rough and probably permanent. The current is swift and somewhat broken by the rough bed and by the remains of old piers. The bench mark is a cross in the stone on the east corner of the base of the right-bank pier of the Knoxville and Augusta Railroad bridge. Its elevation is 2.4 feet above the zero of the gage and 806.7 feet above sea level.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Tennessee River near Knoxville, Tenn., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
February 27	O. P. Hall	890	6,958	3.32	5.70	23,100
July 7	J. M. Giles	644	3,588	1.88	1.42	6,728
August 6	B. S. Drane	668	3,501	1.73	1.26	6,031
October 21	do	629	2,110	.86	— .36	1,813

Mean daily gage height, in feet, of Tennessee River near Knoxville, Tenn, for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.80	0.80	3.80	3.20	4.50	1.10	3.10	0.70	0.60	−0.10	−0.30	0.
2	.70	.80	3.50	3.40	3.70	2.70	2.70	.80	.50	− .10	− .30	.
3	.50	.70	3.30	3.10	3.10	3.10	2.70	1.50	.50	− .20	− .30	.
4	.50	.60	3.60	2.80	2.90	2.80	1.90	1.20	1.00	− .20	− .20	.
5	.50	.60	3.20	2.60	2.70	2.10	1.50	1.40	1.00	− .20	− .20	.
6	.20	.60	2.90	2.30	3.90	1.70	1.20	1.20	1.00	− .20	− .20	2.
7	.10	.70	3.40	2.20	3.30	1.40	1.40	1.30	1.20	− .30	.40	3.
8	.10	2.10	6.60	2.20	2.80	1.50	1.30	1.30	.80	− .30	.40	3.
9	.20	2.60	8.80	2.50	3.00	1.60	1.20	1.50	.60	− .30	.30	2.
10	.40	2.90	6.70	2.60	5.00	1.60	1.60	1.40	.50	− .30	.20	1.
11	.40	2.50	5.40	2.70	4.80	1.30	1.50	1.50	.40	− .30	− .10	1.
12	.40	2.00	4.90	2.40	3.80	1.20	2.00	1.50	.30	− .30	− .20	1.
13	.60	1.70	4.20	2.20	3.30	1.40	1.60	1.70	.20	− .30	− .10	1.
14	.90	1.30	3.90	2.00	2.90	1.20	1.10	1.80	.30	− .20	.00	.
15	1.00	1.20	3.70	2.00	2.70	1.00	.90	1.60	.20	− .30	.20	.
16	1.10	1.10	3.50	2.00	2.40	.90	.80	2.10	.20	− .30	.50	.
17	1.00	1.10	3.10	3.00	2.30	.80	.80	1.40	.10	− .30	.60	.
18	1.10	1.10	2.90	2.90	2.00	.70	.60	1.30	.00	− .30	.50	.
19	1.30	1.00	2.70	2.10	1.90	.70	.70	1.20	.00	− .30	.30	.
20	1.40	1.60	2.60	1.90	1.80	.90	.50	1.00	.00	− .30	.20	.
21	1.10	1.90	2.80	1.90	1.80	1.30	.50	1.20	.00	− .30	.20	.
22	1.00	2.50	4.50	1.90	1.70	1.00	.50	1.30	.00	− .30	.20	.
23	1.80	3.70	7.30	2.00	1.50	1.00	.70	2.10	.00	− .30	.20	.
24	2.60	4.80	12.00	1.90	1.40	1.00	.90	1.60	− .10	− .30	.30	.
25	3.70	4.20	12.60	1.60	1.30	1.00	.90	1.60	− .10	− .40	.40	.
26	2.80	3.20	10.10	1.70	1.20	.80	.80	1.50	− .20	− .40	.30	.
27	2.00	5.20	8.30	1.80	1.10	1.10	.80	1.10	− .20	− .40	.30	.
28	1.50	5.30	7.10	2.50	1.10	1.10	1.70	1.00	− .10	− .30	.20	3.
29	1.20	4.70	6.10	4.30	1.00	1.40	1.30	1.10	− .10	− .30	.00	3.
30	1.10	.....	5.00	5.40	1.00	2.30	.90	1.00	− .10	− .30	.10	3.
31	.90	.....	4.20	.....	1.00	.....	.80	.80	.....	− .30	.....	2.

Rating table for Tennessee River near Knoxville, Tenn., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
−0.4	1,750	1.1	5,500	3.2	12,950	8.0	33,440
− .3	1,930	1.2	5,820	3.4	13,710	8.5	35,840
− .2	2,120	1.3	6,150	3.6	14,480	9.0	38,290
− .1	2,320	1.4	6,480	3.8	15,260	10.0	43,340
.0	2,530	1.5	6,820	4.0	16,040	11.0	48,590
.1	2,750	1.6	7,160	4.2	16,840	12.0	54,040
.2	2,980	1.7	7,500	4.4	17,640	13.0	59,690
.3	3,220	1.8	7,850	4.6	18,450	14.0	65,490
.4	3,470	1.9	8,200	4.8	19,270	15.0	71,290
.5	3,730	2.0	8,550	5.0	20,090	16.0	77,090
.6	4,000	2.2	9,260	5.5	22,190	18.0	88,690
.7	4,280	2.4	9,980	6.0	24,340	20.0	100,290
.8	4,570	2.6	10,710	6.5	26,540	22.0	111,890
.9	4,870	2.8	11,450	7.0	28,790	25.0	129,290
1.0	5,180	3.0	12,190	7.5	31,090		

The above table is applicable only for open-channel conditions. It is based upon discharge measurements made during 1900 to 1904, inclusive. It is well defined. Above gage height 0.4 feet the curve is the same as that for 1903.

Estimated monthly discharge of Tennessee River near Knoxville, Tenn., for 1904.

[Drainage area, 8,990 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	14,870	2,750	5,545	0.617	0.711
February	21,350	4,000	9,377	1.04	1.12
March	57,410	10,710	21,770	2.42	2.79
April	21,770	7,160	10,420	1.16	1.29
May	20,090	5,180	10,430	1.16	1.34
June	12,570	4,280	6,516	.725	.809
July	12,570	3,730	6,095	.678	.782
August	8,900	4,280	6,323	.703	.810
September	5,820	2,120	3,258	.362	.404
October	2,320	1,750	1,968	.219	.252
November	4,000	1,930	2,852	.317	.354
December	14,480	2,980	6,309	.702	.809
The year	57,410	1,750	7,572	.842	11.47

TENNESSEE RIVER AT CHATTANOOGA, TENN.

This station was established in 1879, at the foot of Lookout street, just below Chattanooga Island, by the Signal Corps of the United States Army; but since July 1, 1891, it has been in charge of the Weather Bureau. The gage consists of a sloping section made of railroad rails bolted to solid rock, and a vertical section of heavy timber bolted to the vertical face of rock cliff. During the year 1900 a new gage was established. It is a vertical metal scale bolted to the south side of the third stone pier from the south end of the Hamilton County highway bridge. The original sloping gage, however, is still considered standard as the later gage is not properly adjusted at its lower end on account of the projecting base of the pier. During the present year the self-registering gage invented by Professor Fulton, of Tennessee University, has been in use at this station. The gage is connected by wire with the Weather Bureau office, and a continuous electrical record of river height is made in the same manner as the record of wind, sunshine, etc. Gage heights are furnished to the Geological Survey through L. M. Pindell.

Discharge measurements are made from the steel highway bridge in six spans and an approach about 1,000 feet long on the right bank. The floor of the bridge is about 125 feet above low water. The initial point for soundings is the outside corner of the iron post of the downstream hand rail on the left bank. The channel is curved for 3,000

feet above and 2,000 feet below the station. The right bank is high and overflows at flood stages, but all water passes under the bridge or its approach. The left bank is a high, rocky bluff, and will not overflow. The bed is composed of loose rock, sand, and gravel, and is fairly constant. The bench mark is the top of the water table on the southeast corner of the post-office on Eleventh street. Its elevation is 74.4 feet above the zero of the gage, and 705 feet above sea level.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Tennessee River at Chattanooga, Tenn., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
February 3	J. M. Giles	975	7,395	2.23	2.77	16,480
February 10	do	1,054	10,610	3.36	5.85	35,640
April 19	do	993	8,493	2.94	4.30	24,980
July 6	do	956	6,920	2.54	3.18	17,590
August 5	B. S. Drane	1,114	7,014	2.10	2.73	14,710
October 13	do	1,014	4,375	1.23	.21	5,368
October 14	do	1,016	4,433	1.25	.22	5,558
October 22	do	1,012	4,234	1.15	.06	4,863

Mean daily gage height, in feet, of Tennessee River at Chattanooga, Tenn., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.10	3.40	8.10	9.00	6.00	4.30	3.60	2.20	2.20	0.70	0.10	1.10
2	2.60	3.10	7.40	8.10	7.60	4.10	3.70	2.20	2.00	.70	.10	1.40
3	2.30	2.80	7.00	7.20	6.70	4.30	4.30	2.60	1.80	.60	.20	1.50
4	2.20	2.70	6.60	6.60	5.80	4.40	4.00	2.40	1.80	.50	.40	2.20
5	2.00	2.50	6.10	6.00	5.40	4.90	3.90	2.60	1.70	.40	.50	2.10
6	2.00	2.40	6.20	5.60	5.20	4.90	3.40	2.90	1.70	.50	.50	3.50
7	1.70	2.30	6.10	5.40	4.90	4.50	3.10	3.70	2.20	.40	.60	4.40
8	1.60	3.60	8.00	5.40	5.40	3.80	2.90	3.70	2.40	.30	.60	5.80
9	1.50	4.80	11.00	5.80	5.60	3.70	2.70	3.30	2.20	.20	.60	5.70
10	1.60	5.90	11.30	5.90	6.40	3.70	2.90	3.30	2.00	.30	.90	5.40
11	1.70	5.40	11.10	6.00	7.00	3.40	2.90	3.30	1.80	.30	.90	4.90
12	1.70	5.50	10.10	5.60	7.20	3.20	3.10	3.30	1.60	.30	.90	3.70
13	1.90	4.90	9.00	5.30	6.60	2.80	3.10	4.10	1.40	.30	.80	3.00
14	2.10	4.40	8.50	4.90	5.70	2.60	3.60	3.70	1.30	.20	.60	2.70
15	2.30	3.90	9.10	4.70	5.40	2.50	3.40	3.30	1.20	.20	.60	2.50
16	2.50	3.60	8.90	4.40	5.20	2.50	3.00	3.30	1.10	.20	.70	2.30
17	2.60	3.50	8.10	4.30	4.90	2.40	2.60	4.10	1.00	.20	.80	2.30
18	2.90	3.30	7.10	4.30	4.50	2.20	2.40	3.90	1.00	.20	.90	2.10
19	3.90	3.10	6.60	4.30	4.30	2.10	2.20	3.10	.90	.20	1.00	2.00
20	3.80	3.20	6.10	4.20	4.10	2.00	2.10	2.70	.90	.20	1.10	1.90
21	3.60	3.70	5.80	4.10	3.80	2.00	1.80	2.40	.90	.10	1.00	1.70
22	3.60	5.20	7.40	4.00	3.60	2.10	1.70	2.40	.80	.10	1.00	1.60
23	6.00	6.30	12.90	4.00	3.50	2.60	1.90	2.20	.80	.10	.90	1.50
24	10.60	7.90	18.20	4.00	3.40	2.70	2.20	2.20	.80	.10	1.00	1.40
25	9.20	8.10	21.80	4.00	3.10	2.80	2.10	2.90	.80	.10	1.00	1.30
26	7.50	7.90	20.90	3.80	2.90	2.30	2.00	3.00	.70	.10	1.00	2.10
27	7.10	7.10	19.10	3.70	2.80	2.20	2.20	2.80	.60	.10	1.10	3.00
28	5.80	7.30	16.90	4.10	2.70	2.20	2.40	2.60	.60	.10	1.00	7.00
29	4.80	9.00	14.00	4.60	2.70	2.70	2.10	2.60	.60	.10	1.00	10.20
30	4.20	.....	11.80	4.70	2.60	3.40	2.60	2.50	.60	.10	1.00	9.00
31	3.80	.....	10.30	.....	3.00	.....	2.90	2.30	.....	.10	.....	7.50

DAVIDSONS RIVER NEAR DAVIDSONS RIVER, N. C.

This station was established May 19, 1904, by M. R. Hall. It is located at English Bridge, about 2 miles from Davidsons River, N. C., and about 500 feet above the mouth of Avery Creek. The gage is a 1-inch by 4-inch pine timber fastened to a 2½-inch by 4-inch oak scantling, which is spiked to the downstream side of a maple tree on the left bank, 40 feet below the bridge. It is graduated to feet and tenths and is 10 feet long. The gage is read once each day by J. J. Perry. Discharge measurements are made from the single-span wooden highway bridge, with log abutments. The floor of the bridge is about 12 feet above low water. The initial point for soundings is the edge of the wooden crib abutment on the upstream side at the left bank. The channel is straight for about 500 feet above and below the station. The current is moderately swift. The right bank is high, rocky, wooded, and is not subject to everflow. The left bank is low, but is not subject to overflow. The bed of the stream is composed of rock, mostly loose bowlders and shingle, and is clean and permanent. There is but one channel at all stages. Bench mark No. 1 is two wire nails driven into the downstream side of the tree to which the gage is attached. Its elevation is 4 feet above the zero of the gage. Bench mark No. 2 is a cross cut on the top of solid rock at edge of water, 8 feet below the bridge at right bank. Its elevation is 1.48 feet above the zero of the gage. Bench mark No. 3 is the center of a nail head in third log from bottom of crib at the right bank on the upstream side. Its elevation is 7 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Davidsons River near Davidsons River, N. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
April 20	M. R. Hall	65	105	0.79	1.00	83
May 19	B. S. Drane	66	108	.77	1.05	84
July 19	do	64	88	.46	.78	41
July 19	do	64	86	.47	.78	41
August 17	do	68	99	.72	.99	71
October 4	do	63	86	.47	.79	40
December 8	do	63	88	.57	.85	51
December 8	do	63	88	.62	.85	55

Mean daily gage height, in feet, of Davidsons River near Davidsons River, N. C., for 1904.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.05	0.85	1.05	1.10	0.80	0.75	0.75
2	1.10	.85	1.00	1.10	.80	.75	.75
3	1.05	.80	.90	1.05	.80	.90	.80
4	1.00	.80	1.00	1.05	.80	1.20	.80
5	.95	.80	.90	1.05	.80	1.00	1.15
6	.95	.80	.90	1.00	.80	.80	1.05
7	1.15	.85	.90	1.00	.80	.80	.90
8	1.05	.90	1.10	.95	.80	.80	.85
9	1.00	.85	1.00	1.00	.80	.75	.85
10	.95	.85	1.45	.95	.75	.75	.85
11	1.10	.90	1.50	1.00	.75	.75	.80
12	1.00	.90	1.40	1.00	.75	.75	.80
13	1.00	.90	1.25	1.00	.75	1.10	.80
14	.95	.90	1.10	.95	.75	.85	.80
15	.90	.80	1.05	.95	.75	.80	.80
16	.90	.75	1.05	.90	.75	.80	.80
17	1.00	.85	1.00	.90	.75	.80	.80
18	.95	.80	.95	.90	.75	.80	.80
19	.95	.90	.90	.90	.75	.75	.80
20	.95	1.00	.90	.85	.75	.75	.80
21	.90	1.05	.95	.85	.75	.75	.80
22	.95	.90	1.05	.85	.75	.75	.80
23	.90	.90	1.15	.85	.75	.75	.80
24	.90	.85	1.25	.85	.75	.75	.80
25	.90	.90	1.65	.85	.75	.75	.85
26	.90	.85	1.60	.85	.75	.75	.80
27	.85	.85	1.55	.85	.75	.75	1.30
28	.85	.80	1.40	.85	.75	.75	1.30
29	.95	1.00	1.25	.80	.75	.75	1.10
30	.90	.90	1.20	.80	.75	.80	1.05
31	.....	.95	1.10	.....	.75	.....	1.00

AVERY CREEK AT DAVIDSONS RIVER, N. C.

This station was established as a bench-mark station May 19, 1904, by M. R. Hall. It is located about one-fourth mile above the junction of Avery Creek with Davidsons River and a less distance from the regular gaging station on the latter stream. Discharge measurements are made from the foot log just above the wagon bridge, the section being smoother than that under bridge. The initial point for soundings is the edge of the large rock which forms the left bank. The channel is curved for about 100 feet above the station and straight for 50 feet below, when it curves to the right. The current is swift. The right bank is high, wooded, and not liable to overflow. The left bank is low, wooded, and overflows at high stages. The bed of the stream is rocky along the right bank and sandy for the remainder. It is not liable to change. There is but one channel at all stages. The bench mark is a small shelf chipped in the upper edge of the upstream face of the large rock on the right bank upon which the end of the foot log rests. Its elevation is 5 feet above gage datum.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Avery Creek at Davidsons River, N. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
May 19	B. S. Drane	18	16	0.91	1.79	14.0
July 19	do	18	13	.64	1.63	8.0
August 17	do	18	14.5	1.00	1.77	14.5
October 4	do	18	12.5	.55	1.62	6.8
December 8	do	18	12	.52	1.66	6.3

LITTLE RIVER AT CALHOUN, N. C.

This station was established as a bench-mark station July 19, 1904, by B. S. Drane. It is located at the highway bridge about one-fourth mile from Calhoun post-office, N. C., and about 1 mile above the mouth of Little River. Discharge measurements are made from the upstream side of the two-span wooden bridge. The initial point for soundings is the right end of the upstream guard rail. The channel is curved for about 75 feet above and 100 feet below the station. The current is swift. The right bank is a high rock cliff; the left bank is composed of earth, steep and wooded. Neither bank is liable to overflow. The bed of the stream is composed of rock along the right bank, and of sand for the greater part of the distance. There is one channel at all stages. Possibly a freshet in French Broad River would make a sluggish back water at this station, but this is not liable to occur. Bench mark No. 1 is the upstream end of the horizontal strap binding the upstream guard rail to the girder, 31 feet from the initial point for soundings. Its elevation is 16 feet above datum. Bench mark No. 2 is the upper edge of a small ledge of rock overhanging the water just under a point on the upstream side of the bridge, 6 feet from the initial point for soundings. It is marked by a nick in the rock on either side. Its elevation is 3 feet above datum.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Little River at Calhoun, N. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
July 19	B. S. Drane	36	43	1.16	0.59	50
August 17	do	37	73	1.27	1.00	93
December 8	do	33	67	1.28	1.09	86

MILLS RIVER (NORTH FORK) AT PINKBED, N. C.

This station was established May 18, 1904, by M. R. Hall. It is located at wagon bridge in the village of Pinkbed, N. C., about three-fourths mile below the post-office of that name. The gage is a vertical 1-inch by 4-inch pine timber fastened to a 2-inch by 4-inch oak scantling which is spiked to the log crib on right bank, at upper side of bridge. The gage is 10 feet long, and is graduated to feet and tenths. It is read once each day by C. D. Davenport. Discharge measurements are made from the single, 39-foot span, wagon bridge to which the gage is attached. The bridge rests upon log crib abutments, and the floor is about 10 feet above low water. The initial point for soundings is the edge of crib abutment at the left bank, on the downstream side of the bridge. The channel is straight for about 200 feet above and below the station. The current is swift. Both banks are about 10 feet above low water, and are not liable to overflow. There is a wide, level stretch of land from the left bank to foot of hill. The bed of the stream is composed of loose rock and is probably permanent. There is but one channel at all stages. Bench mark No. 1 is a nail driven in bottom log of crib on right bank at downstream corner of crib. Its elevation is 1.70 feet above the zero of the gage. Bench mark No. 2 is the center of a nail driven in a notch on a small poplar tree on left bank about 40 feet above bridge. Its elevation is 5.70 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Mills River (North Fork) at Pinkbed, N. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 21	M. R. Hall	36	27	1.45	0.70	39
May 18	B. S. Drane	37	31	1.61	.82	50
July 18	do	34	22	1.23	.56	27
August 18	do	34	23	1.40	.64	32
October 3	do	29	17	1.11	.47	19
October 3	do	29	17	1.01	.47	17
December 9	do	33	19	1.17	.52	22
December 9	do	33	19	1.08	.52	20

Mean daily gage height, in feet, of Mills River (North Fork) at Pinkbed, N. C., for 1904.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.80	0.60	0.85	0.60	0.45	0.45	0.45
2	.85	.55	.65	.65	.45	.45	.45
3	.80	.55	.60	.55	.45	.55	.50
4	.70	.50	.65	.55	.45	.90	.50
5	.70	.50	.65	.90	.45	.80	.60
6	.65	.50	.70	.70	.45	.50	.70
7	.90	.50	.75	.65	.45	.50	.60
8	.75	.50	.95	.60	.45	.50	.50
9	.70	.90	.80	.60	.45	.45	.50
10	.70	.70	.85	.55	.45	.45	.55
11	.70	.70	1.35	.60	.45	.45	.50
12	.65	.65	1.15	.60	.45	.45	.50
13	.60	.60	.90	.60	.45	1.00	.50
14	.60	.55	.80	.55	.45	.50	.50
15	.60	.55	.75	.55	.45	.50	.50
16	.60	.55	.70	.55	.45	.50	.50
17	.70	.70	.70	.55	.45	.50	.50
18	.70	.65	.65	.50	.45	.50	.50
19	.70	.55	.60	.50	.45	.50	.45
20	.85	.50	.65	.50	.45	.50	.60
21	.70	.55	.60	.50	.45	.50	.60
22	.75	.55	.60	.50	.45	.50	.60
23	.65	.60	.60	.50	.45	.50	.45
24	.60	.55	.65	.50	.45	.45	.50
25	.60	.55	.65	.50	.45	.45	.50
26	.55	.60	.60	.50	.45	.45	.50
27	.60	.55	.80	.50	.45	.45	.70
28	.65	.55	.75	.50	.45	.45	1.00
29	.65	.55	.65	.45	.45	.45	.70
30	.65	.55	.55	.45	.45	.45	.70
31		.55	.60		.45		.55

Rating table for Mills River (North Fork) at Pinkbed, N. C., from June 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.45	16	0.70	39	0.95	65	1.20	95
.50	20	.75	44	1.00	71	1.25	101
.55	24	.80	49	1.05	77	1.30	107
.60	29	.85	54	1.10	83	1.35	113
.65	34	.90	59	1.15	89		

The above table is applicable only for open-channel conditions. It is based upon 8 discharge measurements made during 1904. It is well defined between gage heights 0.45 feet and 0.85 feet. The table has been extended above gage height 0.85 feet.

Estimated monthly discharge of Mills River (North Fork) at Pinkbed, N. C., for 1904.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
June	59	24	37.8
July	59	20	27.1
August	113	24	42.9
September	59	16	25.3
October	16	16	16.0
November	71	16	22.4
December	71	16	25.3

MILLS RIVER (SOUTH FORK) NEAR SITTON, N. C.

This station was established May 18, 1904, by M. R. Hall. It is located at Sycamore Church, about 1 mile below Sitton's mill, Sitton, N. C. The gage is a vertical 1 by 4 inch pine timber, 10 feet long, graduated to feet and tenths, fastened to a 2 by 4 inch chestnut scantling, which is spiked to a whiteoak tree on the right bank of the river about 40 feet above foot log. The gage faces upstream and can be easily read from the bank. It is read once each day by W. E. Field. Discharge measurements are made from a foot log about 150 feet above ford. The channel above curves about 90 degrees in 500 feet above and is straight for 200 feet below the station. The current is moderately swift, but may be rather sluggish above the station at low stages. Both banks are high and clean and are subject to overflow at extreme high water. The bed of the stream is composed of rock, and is clean and constant. There is but one channel at all stages. Owing to the overflowing of the banks discharge measurements can not be made at high water. Bench mark No. 1 is the center of two nail heads driven into the tree to which the gage is attached, on the side next the river. Its elevation is 5 feet above the zero of the gage. Bench mark No. 2 is the center of nails in root of whiteoak tree on the right bank, 15 feet below the foot log. Its elevation is 5 feet above the zero of the gage. Bench mark No. 3 is nails driven into a beech tree on the right bank about 50 feet below the foot log. Its elevation is 8 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Mills River (South Fork) near Sitton, N. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
April 21	M. R. Hall	47	79	1.04	1.00	82
May 18	B. S. Drane	41	79	1.21	1.09	96
July 18	do	40	68	.72	.81	49
August 18	do	41	74	.93	.98	69
October 3	do	41	65	.56	.76	36
October 3	do	41	65	.54	.76	35
December 9	do	40	66	.72	.82	47
December 9	do	40	66	.74	.82	49

Mean daily gage height, in feet, of Mills River (South Fork) near Sitton, N. C., for 1904.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.20	1.05	1.10	1.15	0.75	0.70	0.80
2	1.20	.95	.90	1.05	.75	.75	.80
3	1.05	.90	.85	1.00	.75	.85	.80
4	1.00	.90	.90	1.90	.75	1.25	.80
5	.95	.90	.90	1.15	.75	1.00	1.15
6	.90	.85	.90	1.00	.75	.90	1.15
7	1.65	.85	1.00	.95	.75	.80	.90
8	1.10	.85	1.10	.90	.75	.80	.85
9	1.00	1.30	1.05	.90	.75	.80	.80
10	.95	1.00	1.10	.95	.75	.75	.80
11	1.15	.95	1.80	1.10	.75	.75	.80
12	1.00	.90	1.65	.95	.75	.75	.80
13	.95	.90	1.30	1.00	.75	1.10	.80
14	.90	.85	1.10	.90	.70	.90	.70
15	1.00	.80	1.05	.90	.70	.80	.80
16	.95	.80	1.25	.90	.70	.80	.80
17	1.05	.90	1.00	.85	.70	.80	.80
18	.95	.80	1.00	.85	.70	.80	.80
19	.95	.80	.95	.85	.70	.80	.80
20	1.10	1.45	1.00	.80	.70	.80	1.00
21	.95	.85	.90	.80	.70	.80	1.00
22	1.00	.90	1.10	.80	.70	.80	1.00
23	.90	.95	1.00	.80	.70	.80	.80
24	.90	.90	.95	.80	.70	.80	.80
25	1.10	.90	1.45	.80	.70	.75	.80
26	1.10	1.00	1.20	.80	.70	.75	.80
27	.90	.90	1.50	.80	.75	.75	1.10
28	1.10	.85	1.30	.80	.70	.75	1.40
29	1.35	.80	1.10	.80	.70	.75	1.10
30	1.20	.85	1.05	.80	.70	.80	1.00
31	.....	.85	1.00	.....	.70	.....	1.00

Provisional rating table for Mills River (South Fork) near Sitton, N. C., from June 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*
0.7	22	1.0	82
.8	42	1.1	102
.9	62		

The above table is applicable only for open-channel conditions. It is based upon 8 discharge measurements made during 1904. It is well defined between gage heights 0.75 feet and 1.10 feet, and can only be considered roughly approximate above 1.1 feet. The rating curve is a tangent, the difference being 20 per tenth.

Estimated monthly discharge of Mills River (South Fork) near Sitton, N. C., for 1904.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
June	212	62	92.0
July	172	42	65.5
August	242	52	104
September	262	42	69.0
October	32	22	26.5
November	132	22	46.3
December	162	22	61.0

PIGEON RIVER AT NEWPORT, TENN.

The station was established September 4, 1900, by E. W. Myers. It is located at the highway bridge in the eastern part of Newport, Tenn., 1 mile from the railroad station and 1 mile above the dam of the Newport Flouring Mill, out of reach of backwater. On April 30, 1903, the old wire gage was replaced by a standard chain gage with inclosed scale fastened to the lower chord of the bridge on the downstream side, approximately at the same location as the old gage. The new gage was made to read the same as the one which it replaced. The gage is read once each day by S. R. McSween. Since it was first established the gage has been damaged several times, and the records are continuous only from December 14, 1902. Discharge measurements are made from the lower side of the single-span steel highway bridge to which the gage is attached. The initial point for soundings is the end of the hand rail over the left bank on the downstream side of the bridge. The channel is straight for about 300 feet above and

200 feet below the station. The section is deep, rough, and irregular in shape; the velocity is poorly distributed and about 50 feet of the total width at low stages is stillwater or has a negative velocity. The section is better for measuring at the Southern Railway bridge, about 300 feet below, at which point some of the measurements have been made. The right bank is low and overflows to some extent, but all water passes beneath the bridge and its approach. The left bank is a high vertical rock cliff. The bed of the stream is rocky near the left bank and sandy near the right bank.

Bench mark No. 1 is the top surface of the outer left corner of the plate at the bottom of the floor-beam hanger to the left of the zero of the gage. When the gage reads zero the water surface is 26.87 feet below this bench mark. Bench mark No. 2 is the top of a copper plug set in cement on the top of a limestone outcrop about 5 feet upstream and 3 feet to the left of the end of the upstream hand rail on the left bank. When the gage reads zero the water surface is 32.61 feet below the top of the bolt.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Pigeon River at Newport, Tenn., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
February 22	B. S. Drane	159	1,203	1.72	2.68	2,070
March 29	do	150	1,132	1.57	2.45	1,775
April 26	do	143	992	.87	1.68	861
July 8	J. M. Giles	110	835	.77	1.27	642
August 20	B. S. Drane	134	854	.50	1.10	425
August 20[a]	do	228	585	.84	1.10	490
October 15	do	125	783	.21	.62	169
October 15[a]	do	221	443	.49	.62	216

[a] At railroad bridge.

Mean daily gage height, in feet, of Pigeon River at Newport, Tenn., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.00	1.15	1.90	2.00	1.85	1.80	1.60	1.10	1.15	0.70	0.60	1.10
2	1.05	1.10	1.85	1.90	1.80	1.70	1.45	1.50	1.25	.65	.60	1.00
3	1.10	1.10	1.80	1.85	1.75	1.65	1.20	1.10	1.20	.65	.65	.90
4	1.00	1.05	1.70	1.80	1.80	1.50	1.20	1.20	1.25	.65	.80	1.00
5	.70	1.10	1.65	1.75	1.75	1.30	1.20	1.40	1.25	.65	1.05	1.20
6	.50	1.15	1.60	1.70	1.70	1.50	1.30	1.55	1.30	.70	.95	2.40
7	1.15	1.50	6.30	1.75	1.60	1.70	1.45	1.50	1.15	.65	.85	1.60
8	1.00	2.40	3.10	1.90	2.00	1.85	1.30	1.30	1.00	.65	.80	1.25
9	.95	2.00	2.50	2.50	2.70	1.50	2.25	1.40	1.00	.65	.70	1.10
10	1.00	1.75	2.35	2.00	2.25	1.35	1.75	1.50	1.00	.65	.65	1.05
11	1.10	1.55	2.30	1.80	2.00	1.30	1.45	1.55	.95	.60	.65	1.00
12	1.25	1.50	2.30	1.75	1.95	1.35	1.75	1.60	.95	.60	.60	1.00
13	1.20	1.40	2.10	1.70	1.90	1.35	1.50	1.70	.95	.60	.70	1.00
14	1.10	1.40	2.05	1.60	1.85	1.25	1.25	1.40	.90	.60	.80	.95
15	1.10	1.35	2.00	1.65	1.80	1.20	1.25	1.35	.85	.60	.90	.90
16	1.15	1.30	2.00	1.70	1.70	1.20	1.15	1.40	.80	.55	.85	.90
17	1.15	1.30	1.90	1.70	1.60	1.15	1.30	1.15	.80	.55	.80	.90
18	1.15	1.30	1.90	1.65	1.60	1.20	1.20	1.05	.80	.55	.80	.85
19	1.15	1.30	1.90	1.60	1.55	1.20	1.10	1.05	.80	.55	.75	.85
20	1.20	1.40	1.80	1.50	1.50	1.30	1.00	1.10	.80	.60	.75	.70
21	1.25	1.40	2.00	1.75	1.45	1.50	1.00	1.10	.75	.60	.80	.65
22	2.65	2.65	2.50	1.85	1.35	1.40	1.40	1.15	.75	.55	.80	.65
23	3.15	2.25	5.10	1.75	1.35	1.40	1.50	1.50	.75	.55	.90	.60
24	2.00	1.85	2.30	1.60	1.35	1.20	1.45	1.40	.70	.55	1.00	.90
25	1.75	1.20	2.20	1.60	1.40	1.25	1.40	1.30	.70	.60	.90	.95
26	1.60	1.65	2.80	1.60	1.40	1.25	1.30	1.40	.70	.60	.80	1.00
27	1.50	2.70	2.95	1.95	1.35	1.35	1.20	1.30	.75	.60	.75	1.05
28	1.40	2.20	2.75	2.00	1.30	1.45	1.05	1.25	.75	.60	.75	3.05
29	1.30	2.00	2.45	2.00	1.25	1.50	1.00	1.20	.75	.60	.75	1.90
30	1.25	.....	2.30	2.00	1.20	1.70	1.00	1.15	.70	.60	1.20	1.70
31	1.20	.....	2.15	.....	2.20	.....	1.05	1.10	.....	.60	.....	1.40

Rating table for Pigeon River at Newport, Tenn., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.6	180	1.5	710	2.4	1,660	3.3	3,300
.7	225	1.6	790	2.5	1,810	3.4	3,500
.8	275	1.7	875	2.6	1,970	3.5	3,700
.9	325	1.8	965	2.7	2,140	3.6	3,900
1.0	380	1.9	1,060	2.8	2,320	3.7	4,100
1.1	440	2.0	1,160	2.9	2,510	3.8	4,300
1.2	500	2.1	1,270	3.0	2,700	3.9	4,500
1.3	565	2.2	1,390	3.1	2,900	4.0	4,700
1.4	635	2.3	1,520	3.2	3,100	5.0	6,700

The above table is based upon measurements made 1900 to 1904, and is well defined. Above gage height 3 feet the rating curve is a tangent, the difference being 200 per tenth.

Estimated monthly discharge of Pigeon River at Newport, Tenn., for 1904.

[Drainage area, 655 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	3,000	140	635	0.969	1.12
February	2,140	410	846	1.29	1.39
March	9,300	790	1,859	2.84	3.27
April	1,810	710	974	1.49	1.66
May	2,140	500	895	1.37	1.58
June	1,012	470	653	.997	1.11
July	1,455	380	598	.913	1.05
August	875	410	583	.890	1.03
September	565	225	340	.519	.579
October	225	160	184	.281	.324
November	500	180	275	.420	.469
December	2,800	180	529	.808	.932
The year	9,300	140	698	1.07	14.51

NOLICHUCKY RIVER NEAR GREENEVILLE, TENN.

This station was established May 7, 1903, by E. W. Myers, assisted by B. S. Drane. It is located at Jones's bridge, 5 miles southeast of Greeneville, Tenn., which is the nearest railroad station. The standard chain gage, with inclosed scale, is nailed to wooden blocks bolted to the lower chord of the bridge on the upstream side midway between the second and third intermediate post from the right bank. The length of the chain from the end of the weight to the marker is 33.63 feet. The gage is read once each day by B. H. Jones. Discharge measurements are made from the downstream side of the two-span steel highway bridge to which the gage is attached. The initial point for soundings is the left end of the top bar of the downstream hand rail. The channel is straight for about 700 feet above and below the station. The right bank is high, but at flood stages part of the water will pass around the end of the bridge. The left bank is high and can never overflow. The section is regular, and the bed is composed of pebbles and small stones and is not subject to change. The velocity is uniform and well distributed except at extreme low water (below gage height 0.50 foot), when the middle pier and a small bar of gravel and small stones throw the current toward both banks.

Bench mark No. 1 is a standard iron bench-mark post of the United States Geological Survey set on the left bank just below the bridge. It is 5.5 feet downstream from the left end of the bridge, and is said

to be above high-water mark. Its elevation above gage datum is 26.80 feet. Bench mark No. 2 is the upper outer edge of the outer eyebar of the lower chord of the bridge, 3.6 feet to the right of the center of the third intermediate post from the right bank. The point is marked by a spot of white paint and the letters "B. M." Its elevation above gage datum is 32.03 feet.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Nolichucky River near Greeneville, Tenn., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
February 24	B. S. Drane	275	1,015	1.57	1.11	1,592
February 27	do	274	1,157	2.21	1.69	2,52[illegible]
March 23	do	275	1,558	3.45	3.26	5,3[illegible]
March 23	do	275	1,732	3.84	3.66	6,657
March 24	do	311	2,008	3.99	4.67	8,01[illegible]
May 3	do	133	987	1.56	1.11	1,542
July 9	J. M. Giles	264	806	1.07	.48	8[illegible]
August 9	B. S. Drane	275	911	1.24	.81	1,129
August 9	do	275	914	1.34	.82	1,222
October 17	do	275	649	.52	— .12	34[illegible]
October 17	do	275	646	.55	— .10	355

Mean daily gage height, in feet, of Nolichucky River near Greeneville, Tenn., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.11	0.20	1.40	1.40	1.40	1.75	1.30	0.30	0.25	0.00	−0.10	0.[illegible]
2	.12	.20	1.40	1.40	1.25	1.95	.90	1.45	.50	— .05	— .05	.[illegible]
3	.30	.18	1.30	1.25	1.15	1.55	.65	.95	.65	— .10	— .05	.[illegible]
4	.18	.30	1.20	1.05	1.20	1.15	.50	.65	.60	— .05	.00	.[illegible]
5	.06	.20	1.20	1.00	1.40	.95	.70	.50	.50	— .10	.25	.[illegible]
6	.10	.15	1.00	.95	1.20	.85	.50	.65	.40	— .10	.55	1.[illegible]
7	.04	.30	3.10	1.00	1.05	.90	.50	.60	.30	— .10	.30	1.[illegible]
8	.12	1.80	3.70	1.00	.90	.80	.45	.70	.25	.00	.10	.[illegible]
9	.11	1.40	2.40	.95	3.70	.75	.50	.80	.20	— .05	.05	.[illegible]
10	.09	.90	1.80	1.15	2.30	.60	1.00	.65	.15	— .05	.00	.45
11	.12	.70	1.65	.95	1.70	.85	.65	.75	.15	— .05	.00	.[illegible]
12	.20	.60	1.60	.90	1.45	.75	.85	1.05	.15	— .05	.00	.55
13	.30	.40	1.40	.90	1.35	.70	.65	.80	.15	— .10	.10	.[illegible]
14	.30	.40	1.25	.80	1.15	.55	.50	.65	.20	— .10	.55	.[illegible]
15	.19	.40	1.25	.75	1.05	.50	.35	.50	.10	— .10	.55	.[illegible]
16	.10	.60	1.10	.80	1.00	.40	.30	.65	.10	— .10	.30	.[illegible]
17	.80	.40	.95	1.20	.90	.45	.35	.60	.05	— .10	.25	.[illegible]
18	.70	.30	.95	1.00	.85	.55	.35	.55	.05	— .10	.30	.[illegible]
19	.50	.40	1.05	.85	.95	.65	.25	.40	.05	— .10	.20	.[illegible]
20	.30	.50	1.00	.80	.85	.75	.20	.55	.05	— .10	.15	.[illegible]
21	.30	.60	.95	.80	.80	.75	.20	.75	.05	— .10	.20	.10
22	.30	.60	2.10	.80	.75	.70	.70	.90	.05	— .10	.20	.[illegible]
23	1.00	1.70	2.10	.75	.65	.55	.45	.65	.00	— .15	.25	.15
24	1.00	1.20	5.00	.75	.60	.45	.30	.75	.00	— .10	.40	.15
25	.90	.90	3.30	.80	.60	.40	.25	1.00	.00	— .10	.30	.[illegible]
26	.50	.90	2.50	.75	.60	.50	.90	.55	.00	— .10	.20	.50
27	.40	1.50	2.40	1.50	.70	.85	.70	.45	.00	— .10	.15	.[illegible]
28	.30	2.20	2.30	2.25	.65	.60	.40	.45	.00	— .05	.10	.[illegible]
29	.30	1.60	1.90	1.90	.55	1.95	.45	.35	.00	— .05	.05	1.55
30	.30	.....	1.70	1.65	.55	1.55	.50	.30	.00	— .05	.20	.[illegible]
31	.20	.....	1.50	.....	.60	.....	.45	.25	.00	— .10	.....	.55

Rating table for Nolichucky River near Greeneville, Tenn., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.15	320	0.8	1,195	1.9	2,780	3.0	4,860
.1	355	.9	1,305	2.0	2,955	3.2	5,270
.05	390	1.0	1,420	2.1	3,135	3.4	5,680
.0	430	1.1	1,545	2.2	3,315	3.6	6,100
.1	510	1.2	1,675	2.3	3,500	3.8	6,530
.2	595	1.3	1,815	2.4	3,685	4.0	6,960
.3	685	1.4	1,965	2.5	3,875	4.2	7,390
.4	780	1.5	2,120	2.6	4,070	4.4	7,820
.5	880	1.6	2,280	2.7	4,265	4.6	8,250
.6	980	1.7	2,445	2.8	4,460	4.8	8,690
.7	1,085	1.8	2,610	2.9	4,660	5.0	9,130

The above table is applicable only for open-channel conditions. It is based upon 18 discharge measurements made during 1903 and 1904. It is well defined between gage heights —0.15 feet and 1.10 feet. Above 1.10 feet the curve is somewhat uncertain owing to the fluctuation of the water surface during the high-water measurements.

Estimated monthly discharge of Nolichucky River near Greeneville, Tenn., for 1904.

[Drainage area, 1,099 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	1,420	462	711	0.647	0.746
February	3,315	553	1,210	1.10	1.19
March	9,130	1,363	2,778	2.53	2.92
April	3,408	1,140	1,549	1.41	1.57
May	6,315	930	1,631	1.48	1.71
June	2,868	780	1,313	1.19	1.33
July	1,815	595	931	.847	.976
August	2,043	640	1,045	.951	1.10
September	1,033	430	573	.521	.581
October	430	320	369	.336	.387
November	930	355	588	.535	.597
December	1,890	510	869	.791	.912
The year	9,130	320	1,131	1.03	14.01

HOLSTON RIVER (SOUTH FORK) AT BLUFF CITY, TENN.

This station was originally established by the United States Weather Bureau at the highway bridge at Bluff City, Tenn. Readings were begun July 17, 1900, by the United States Geological Survey in connection with the general hydrographic investigation of the Southern Appalachian region. The gage, which is the property of the United States Weather Bureau, is a 4 by 8 inch timber bolted to the downstream side of the first channel pier from the right bank. The gage readings are furnished by the United States Weather Bureau. Discharge measurements are made from the lower side of the four-span highway bridge to which the gage is attached. This bridge is a short distance below the Virginia and Southwestern Railroad bridge. The initial point for soundings is the end of the guard rail on the downstream side of the bridge over the left abutment. The channel is straight above the bridge for a distance of 300 feet, to the bridge of the Virginia and Southwestern Railroad. The channel is straight for about 1,000 feet below the bridge. The bed is rocky and permanent. The bottom is very rough, and rocky ledges just above and below the bridge cause back currents, eddies, and sudden variations in the velocity. Both banks are high and do not overflow. The gage is referred to a United States Geological Survey bronze bench-mark tablet set in the upstream side of the capstone of the left abutment. When the gage reads zero, this bench mark is 20.44 feet above the water surface. Its elevation above sea level is 1,389 feet.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Holston River (South Fork) at Bluff City, Tenn., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
February 26	B. S. Drane	265	590	1.89	1.62	1,114
March 28	do	268	763	1.98	2.38	1,509
April 29	Drane and M. R. Hall	275	955	3.04	3.27	2,900
July 12	J. M. Giles	97	273	1.68	.60	459
July 12[a]	do	123	490	.97	.60	475
August 10	B. S. Drane	204	252	1.52	.60	384
October 18	do	196	181	.89	— .05	162
October 18	do	108	73	2.35	— .05	171
October 18[a]	do	112	349	.48	— .09	168

[a] Measurement made at Virginia and Southwestern Railroad bridge.

Mean daily gage height, in feet, of Holston River (South Fork) at Bluff City, Tenn., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.30	0.70	1.60	1.65	2.40	0.90	1.80	0.40	0.00	0.10	−0.10	0.30
2	.40	.20	1.80	1.60	2.10	.90	1.30	2.00	.20	.10	.00	.30
3	.60	.50	2.00	1.45	2.00	1.00	1.00	1.60	.40	.10	.00	.40
4	.30	.40	2.00	1.20	3.00	.90	.90	1.20	.60	.10	.10	.60
5	.10	.10	1.90	1.20	2.85	.70	.80	.90	.70	.10	.30	.70
6	.40	.40	1.70	1.10	2.30	.70	.70	1.00	.60	.10	.30	2.80
7	.40	.50	1.70	1.10	1.95	.60	.70	.90	.40	.10	.20	1.80
8	.40	1.90	3.20	1.25	1.75	.70	.60	.70	.20	.10	.20	1.80
9	.40	2.00	3.00	1.10	1.90	.60	.60	.60	.20	.00	.10	.90
10	.20	1.50	2.40	1.00	2.00	.60	.80	.60	.10	.00	.10	.80
11	.10	1.40	2.10	1.00	2.00	.60	.80	.70	.20	.00	.10	.80
12	.90	1.10	2.20	1.00	1.80	.60	.60	1.60	.20	.00	.00	.90
13	.90	.80	1.90	1.10	1.60	.60	.50	1.20	.10	.00	.20	.80
14	.90	.90	1.90	1.55	1.40	.50	.70	1.00	.10	.00	.50	.80
15	.70	1.00	1.80	1.50	1.50	.50	.40	.80	.10	.00	.50	.50
16	.60	1.00	1.75	1.50	1.45	.50	.30	.70	.10	−.10	.40	.60
17	1.00	.80	1.50	1.40	1.20	.50	.90	.60	.10	−.10	.30	.60
18	1.00	.50	1.65	1.10	1.10	.50	.50	.50	.10	−.10	.30	.60
19	.90	.80	1.60	1.20	1.20	.50	.40	.50	.10	−.10	.30	.50
20	.90	1.10	1.60	1.00	1.20	.40	.40	.80	.10	.00	.20	.50
21	.80	1.10	1.55	1.00	1.20	.40	.30	.70	.10	−.10	.20	.40
22	.80	1.60	1.80	1.00	1.10	.40	.30	.70	.10	−.10	.20	.40
23	1.70	3.10	3.10	1.00	1.00	.40	.30	.70	.10	−.10	.40	.30
24	1.80	2.40	5.70	.90	.90	.40	.40	.50	.10	−.10	.40	.30
25	1.40	1.90	3.90	.90	.90	.30	.70	.40	.10	−.10	.40	.70
26	1.30	1.60	3.00	.90	.80	.30	.60	.40	.00	.00	.30	.90
27	1.10	1.60	2.75	2.00	.80	.40	.50	.40	.00	−.10	.20	.90
28	.80	1.50	2.60	4.20	.70	.80	.60	.30	.10	.00	.10	2.00
29	.70	1.50	2.10	3.60	.80	1.70	.50	.20	.10	−.10	.10	1.50
30	.40	.....	2.00	2.90	.80	2.50	.50	.20	.10	−.10	.20	1.00
31	.40	.....	1.70	.....	.80	.....	.40	.00	.....	−.10	.....	.90

Rating table for Holston River (South Fork) at Bluff City, Tenn., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
−0.1	150	1.2	840	2.5	1,970	3.8	3,800
.0	190	1.3	910	2.6	2,080	3.9	3,980
.1	235	1.4	980	2.7	2,190	4.0	4,160
.2	280	1.5	1,060	2.8	2,310	4.2	4,530
.3	330	1.6	1,140	2.9	2,430	4.4	4,910
.4	380	1.7	1,220	3.0	2,550	4.6	5,310
.5	430	1.8	1,300	3.1	2,680	4.8	5,730
.6	485	1.9	1,390	3.2	2,820	5.0	6,180
.7	540	2.0	1,480	3.3	2,970	5.2	6,650
.8	595	2.1	1,570	3.4	3,120	5.4	7,130
.9	650	2.2	1,670	3.5	3,280	5.6	7,630
1.0	710	2.3	1,770	3.6	3,450	5.8	8,130
1.1	770	2.4	1,870	3.7	3,620	6.0	8,630

The above table is applicable only for open-channel conditions. It is based upon 41 discharge measurements made during 1900 to 1904, inclusive. It is well defined between gage heights −0.1 feet and 3.5 feet. The table has been extended beyond these limits. Above gage height 5.4 feet the rating curve is a tangent, the difference being 250 per tenth.

Estimated monthly discharge of Holston River (South Fork) at Bluff City, Tenn., for 19

[Drainage area, 828 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	1,300	235	573	0.692	0.7
February	2,680	235	885	1.07	1.1
March	7,880	1,060	1,860	2.25	2.5
April	4,530	650	1,086	1.31	1.4
May	2,550	540	1,115	1.35	1.5
June	1,970	330	550	.664	.74
July	1,300	330	515	.622	.71
August	1,480	190	579	.699	.8
September	540	190	274	.331	.3
October	235	150	185	.223	.2
November	430	150	291	.351	.3
December	2,310	330	651	.786	.9
The year	7,880	150	714	.862	11.7

HOLSTON RIVER AT AUSTINS MILLS, NEAR ROGERSVILLE, TENN.

This station is maintained in cooperation with the United States Weather Bureau, by whom the gage readings are furnished. It is located at the Southern Railway bridge at Austins Mills, Tennessee. The gage is graduated by feet and tenths to 49 feet, and is attached vertically to the downstream end of the pier nearest the right bank. It is read once each day by Fred Beal. Discharge measurements are made from the downstream side of the bridge to which the gage is attached. This is a deck bridge, 800 feet long, resting on stone piers. Six spans are wooden truss, and piers have been built for two more spans at each end, but the track is carried on trestle work. The initial point for soundings is the end of the bridge truss over the center of the pier on the right bank, downstream side. The channel is straight for about 2,000 feet above and for 1,000 feet below the bridge. The current is swift, there being a shoal about 500 feet below the bridge. The right bank will overflow gradually at gage heights from 10 to 20 feet, and the left bank at gage heights 8 to 20 feet. There is a fringe of trees along both banks. The bed of the stream is composed of rock and gravel and is permanent. All the water passes beneath the bridge and trestles, there being one channel broken by three piers at ordinary stages.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Holston River at Austins Mills, near Rogersville, Tenn., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
July 14	J. M. Giles	376	1,526	1.17	1.75	1,783
August 12	B. S. Drane	420	1,591	1.47	2.00	2,332
October 21	do	413	1,229	.53	1.10	647

Mean daily gage height, in feet, of Holston River at Austins Mills, near Rogersville, Tenn., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.80	1.70	2.90	3.00	3.70	2.00	3.10	1.60	1.40	1.20	1.00	1.30
2	1.50	1.60	3.10	2.90	3.30	2.70	2.80	1.60	1.40	1.20	1.00	1.30
3	1.60	1.60	3.70	2.60	3.10	2.80	2.20	2.40	1.40	1.20	1.00	1.50
4	1.60	1.50	3.10	2.40	3.00	2.40	2.10	2.30	1.80	1.20	1.10	1.60
5	1.60	1.50	3.10	2.30	4.30	2.20	2.10	2.00	1.90	1.20	1.20	1.70
6	1.70	1.50	2.90	2.30	3.60	2.20	2.10	2.00	1.60	1.20	1.30	3.10
7	1.60	1.60	2.90	2.30	3.20	2.10	2.20	2.00	1.60	1.20	1.40	3.40
8	1.60	2.00	5.00	2.30	2.60	2.10	2.10	1.90	1.50	1.10	1.30	2.60
9	1.80	3.10	4.50	2.40	3.00	2.10	2.10	1.80	1.50	1.10	1.30	2.20
10	1.60	2.80	3.90	2.40	3.40	2.00	2.00	1.80	1.40	1.10	1.20	2.00
11	1.60	2.50	3.50	2.30	3.30	2.50	2.20	1.70	1.40	1.10	1.20	1.80
12	1.70	2.20	3.40	2.20	3.10	2.20	2.00	1.70	1.40	1.10	1.20	1.80
13	1.80	2.00	3.10	2.20	3.00	2.10	1.90	2.20	1.40	1.10	1.30	1.90
14	2.00	1.80	3.10	2.40	2.70	1.90	1.80	2.00	1.40	1.10	1.30	1.80
15	2.00	1.80	3.10	2.40	2.60	1.90	1.70	2.00	1.30	1.10	1.50	1.70
16	1.80	1.80	3.10	2.40	2.50	1.80	1.70	2.10	1.30	1.10	1.50	1.70
17	2.00	1.80	2.80	2.30	2.40	1.80	1.60	1.80	1.30	1.10	1.40	1.70
18	2.20	1.70	2.60	2.40	2.30	1.80	1.50	2.00	1.30	1.10	1.30	1.60
19	2.20	1.70	2.50	2.30	2.30	1.80	1.50	1.80	1.20	1.10	1.30	1.50
20	2.00	2.10	2.50	2.20	2.20	1.80	1.50	1.90	1.20	1.10	1.30	1.50
21	1.80	2.20	2.50	2.10	2.20	1.70	1.50	2.70	1.20	1.10	1.30	1.50
22	1.80	2.20	3.20	2.00	2.20	1.70	1.50	2.60	1.20	1.10	1.30	1.50
23	2.30	3.80	3.70	2.00	2.20	1.70	1.50	2.20	1.20	1.00	1.40	1.50
24	3.40	3.80	7.00	2.00	2.20	1.70	1.50	1.80	1.20	1.00	1.40	1.40
25	3.00	3.20	6.50	2.00	2.10	1.70	1.50	1.70	1.20	1.00	1.30	1.70
26	2.50	3.00	5.00	2.00	2.10	1.70	1.70	1.60	1.20	1.00	1.50	1.80
27	2.30	3.10	4.40	2.20	2.10	1.60	1.70	1.50	1.20	1.00	1.40	2.00
28	2.20	3.30	4.10	3.70	2.00	1.80	1.70	1.50	1.20	1.00	1.30	2.80
29	1.80	3.00	3.70	5.00	1.80	2.40	1.70	1.50	1.20	1.00	1.30	3.20
30	1.70	.....	3.50	4.30	1.80	2.90	1.70	1.40	1.20	1.00	1.30	2.60
31	1.70	.....	3.10	.....	1.80	.....	1.60	1.40	.....	1.00	.....	2.40

Rating table for Holston River at Austins Mills, near Rogersville, Tenn., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.1	645	1.7	1,695	2.3	3,035	2.9	4,675
1.2	805	1.8	1,900	2.4	3,285	3	4,980
1.3	970	1.9	2,110	2.5	3,545	3.1	5,290
1.4	1,140	2	2,330	2.6	3,815	3.2	5,610
1.5	1,315	2.1	2,555	2.7	4,095	3.3	5,940
1.6	1,500	2.2	2,790	2.8	4,380	3.4	6,270

The above table is applicable only for open-channel conditions. It is based upon 3 discharge measurements made during 1904 and one made in 1905. It is well defined between gage heights 1.1 feet and 2 feet. The table has been extended above these limits.

Estimated monthly discharge of Holston River at Austins Mills, near Rogersville, Tenn., for 1904.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
January	6,270	1,315	2,273
February	7,590	1,315	3,169
March	18,150	3,545	7,007
April	11,550	2,330	3,704
May	9,240	1,900	4,096
June	4,675	1,500	2,460
July	5,290	1,315	2,093
August	4,095	1,140	2,125
September	2,110	805	1,077
October	805	490	636
November	1,315	490	952
December	6,270	970	2,325
The year	18,150	490	2,660

WATAUGA RIVER NEAR ELIZABETHTON, TENN.

This station was established May 11, 1903, by E. W. Myers, assisted by B. S. Drane. The station is located on the Virginia and Southwestern Railroad bridge at Siam, about 4 miles from Elizabethton, Tenn. The standard inclosed chain gage is located on the downstream side of the middle span on the inside of the guard rail. The zero of the scale is opposite a point 142 feet from the initial point for soundings. The length of the chain from the end of the weight to the marker is 22.66 feet. It is read once each day by J. B. Nave. Discharge measurements are made on the lower side of the bridge to which the gage is attached. This bridge crosses the river at an angle of about 14° with the normal to the direction of the current. The initial point for soundings is the top of the first bolt on the downstream guard rail over the middle of the left abutment. The channel is straight for 1,000 feet above and below the station. The right bank is high and will overflow only at flood stages. All water will, however, pass under the bridge and the trestle approach. The left bank is a perpendicular masonry abutment and will not overflow. The section underneath the bridge is smooth and consists of sand, silt, and some small rocks, and does not appear to be shifting. At ordinary stages the channel is divided into three parts by the bridge piers. At flood stages there is an additional flood channel on the right bank. A shallow stretch 1,000 feet below the bridge makes the current under

the bridge sluggish at low stages. Bench mark No. 1 is a standard copper bolt set in the cap of the abutment on the left bank, upstream side of the bridge. When the gage reads zero its elevation is 21.11 feet above the water surface. Bench mark No. 2 is the upper edge of the plate connecting the lower bracing system with the lower chord and floor beam opposite the middle of the gage box on the downstream side of the bridge. This floor beam is the fourth from the left end of the middle span. When the gage reads zero its elevation is 19.60 feet above the water surface. During the summer and fall of 1902 a line of levels was run from Carter's station, Tennessee, near the mouth of the river, to a point near Shulls Mills, in North Carolina, near the head of the river, locating the water powers of this stream. These powers are numerous and of considerable magnitude, but at present are comparatively inaccessible and hence not commercially available.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Watauga River near Elizabethton, Tenn., in 1903 and 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		*Feet.*	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
February 10	E. W. Myers	233	1,002	1.09	2.80	1,095
May 11	do	229	762	.87	2.00	665
July 13	B. S. Drane	228	662	.35	1.61	234
August 15	do	229	653	.31	1.38	205
August 15	M. R. Hall	205	620	.53	1.38	328
September 5	B. S. Drane	228	633	.36	1.25	226
September 5 [a]	do	108	369	.67	1.25	247
October 17	do	228	625	.33	1.20	204
November 23	do	228	633	.34	1.26	214
1904.						
February 25	B. S. Drane	229	788	.68	2.03	537
February 25	do	229	784	.65	2.01	507
March 25	do	234	1,183	2.12	3.70	2,507
April 30	do	230	751	.96	2.15	720
July 11	J. M. Giles	189	594	.68	1.60	403
August 11	B. S. Drane	231	760	.99	2.13	754
October 19 [b]	do	109	311	.51	1.06	158
October 19	do	228	517	.30	1.06	156

[a] Boat three-fourths mile above station. [b] Boat one-half mile above station.

Mean daily gage height, in feet, of Watauga River near Elizabethton, Tenn., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec
1	1.30	1.50	2.35	2.05	2.10	2.50	2.00	2.20	1.40	1.15	1.05	
2	1.30	1.70	2.60	2.00	2.00	3.00	1.80	2.20	1.70	1.15	1.05	
3	1.25	1.60	2.30	2.00	2.70	2.30	1.70	2.10	1.60	1.15	1.10	
4	1.25	1.50	2.30	1.90	3.70	2.20	1.60	2.00	1.50	1.15	1.20	
5	1.20	1.40	2.15	1.80	2.70	2.10	2.70	1.60	1.60	1.15	1.50	
6	1.15	1.60	2.00	1.75	2.40	2.00	1.90	1.75	1.50	1.10	1.50	
7	1.20	1.50	4.45	1.80	2.20	2.20	1.70	1.75	1.45	1.10	1.30	
8	1.20	2.70	3.90	1.70	2.90	1.95	1.60	1.70	1.40	1.10	1.20	1.50
9	1.20	2.20	3.10	2.20	3.50	1.80	1.50	1.65	1.30	1.10	1.15	1.40
10	1.20	1.90	2.60	1.90	3.00	1.80	1.70	1.50	1.30	1.10	1.10	1.50
11	1.30	1.80	2.80	1.85	2.80	1.80	1.60	2.15	1.25	1.10	1.10	1.60
12	1.50	1.65	2.30	1.90	2.50	1.80	1.60	1.90	1.25	1.10	1.10	1.60
13	1.50	1.65	2.30	1.80	2.40	1.70	1.55	1.70	1.30	1.10	1.40	1.50
14	1.40	1.65	2.20	1.70	2.20	1.70	1.50	1.65	1.30	1.10	1.45	1.50
15	1.20	1.70	2.15	1.70	2.25	1.60	1.45	1.70	1.35	1.10	1.50	1.40
16	1.35	1.70	2.10	1.80	2.10	1.50	1.40	2.60	1.30	1.10	1.50	1.40
17	1.80	1.60	2.00	1.85	2.00	1.60	1.40	2.00	1.25	1.10	1.45	1.40
18	1.70	1.60	1.95	1.75	2.60	1.60	1.40	1.70	1.20	1.10	1.45	1.35
19	1.70	1.60	2.00	1.70	2.40	1.50	1.40	1.60	1.20	1.10	1.40	1.35
20	1.40	1.70	2.00	1.70	2.10	1.50	1.30	1.60	1.20	1.05	1.35	1.30
21	1.50	1.70	2.00	1.65	2.00	1.60	1.30	2.00	1.20	1.05	1.35	1.30
22	1.70	2.45	2.35	1.65	1.90	1.70	1.40	1.80	1.15	1.05	1.40	1.50
23	3.00	2.40	4.00	1.60	1.80	1.60	1.50	1.60	1.15	1.05	1.40	1.30
24	2.10	2.20	5.20	1.60	1.75	1.50	1.55	1.50	1.15	1.05	1.40	1.30
25	1.90	2.05	4.00	1.55	1.90	1.45	1.85	1.50	1.15	1.05	1.35	1.50
26	1.90	2.00	3.10	1.65	1.35	1.45	1.80	1.45	1.15	1.05	1.35	1.60
27	1.50	2.60	2.85	1.90	1.30	1.50	1.50	1.45	1.15	1.05	1.30	1.65
28	1.50	2.75	2.60	2.30	1.20	1.70	1.60	1.45	1.15	1.05	1.30	1.70
29	1.55	2.40	2.40	2.80	1.20	2.80	1.50	1.40	1.15	1.05	1.30	1.65
30	1.40	.....	2.20	2.20	1.20	2.20	1.50	1.40	1.15	1.05	1.30	1.60
31	1.40	.....	2.10	.....	2.30	.....	1.60	1.40	.....	1.05	.....	1.60

Rating table for Watauga River near Elizabethton, Tenn., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.0	135	2.0	650	3.0	1,530	4.0	3,025
1.1	170	2.1	720	3.1	1,645	4.2	3,390
1.2	210	2.2	790	3.2	1,765	4.4	3,770
1.3	250	2.3	865	3.3	1,895	4.6	4,160
1.4	295	2.4	945	3.4	2,035	4.8	4,560
1.5	345	2.5	1,030	3.5	2,180	5.0	4,960
1.6	400	2.6	1,120	3.6	2,335	5.2	5,360
1.7	460	2.7	1,215	3.7	2,500		
1.8	520	2.8	1,315	3.8	2,670		
1.9	585	2.9	1,420	3.9	2,845		

The above table is applicable only for open-channel conditions. It is based upon 12 discharge measurements made during 1903 and 1904. It is not well defined. The table has been extended above gage height 3.7 feet. This table is very uncertain above gage height 3.0 feet.

Estimated monthly discharge of Watauga River near Elizabethton, Tenn., for 1904.

[Drainage area, 408 square miles].

Month.	Discharge in second-feet.			Run-off.	
	Maxtmum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	1,530	190	372	0.912	1.05
February	1,265	295	601	1.47	1.59
March	5,360	618	1,357	3.33	3.84
April	865	372	552	1.35	1.51
May	2,500	210	873	2.14	2.47
June	1,530	320	579	1.42	1.58
July	1,215	250	417	1.02	1.18
August	1,120	295	496	1.22	1.41
September	460	190	254	.623	.695
October	190	152	166	.407	.469
November	345	152	258	.632	.705
December	865	230	349	.855	.986
The year	5,360	152	523	1.28	17.48

DOE RIVER AT ELIZABETHTON, TENN.

This station was established as a bench-mark station May 22, 1904, by B. S. Drane. It is located at the covered wagon bridge in the town of Elizabethton, Tenn. Discharge measurements are made from the downstream side of the bridge by lowering the meter between the sill and the edge of the floor. The initial point for soundings is the left bank end of the downstream hand rail. The channel is straight for 500 feet above and below the station. The current is extremely sluggish at low water. Both banks are high and do not overflow. All the water passes between the stone abutments of the bridge. The bed of the stream is composed of sand, and is very shifting. There is but one channel at all stages. A low dam about 300 feet below the bridge will affect the flow considerably at low stages. The bench mark is the top of the lower downstream hand rail opposite the tension rods at the middle of the bridge, 65 feet from the initial point for soundings. Its elevation is 16 feet above gage datum.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Doe River at Elizabethton, Tenn., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
May 22	B. S. Drane	128	253	1.21	1.55	307
July 11	J. M. Giles	129	166	.60	.79	99
October 20	B. S. Drane	134	131	.37	.64	49

LITTLE TENNESSEE RIVER AT JUDSON, N. C.

This river rises in the extreme northeast Georgia, with tributaries from the mountains between North Carolina and Georgia, and flows in a northwesterly direction, emptying into Tennessee River at Lenoir, Tenn. Measurements of flow are made at Judson, N. C., below the mouth of Sawyer Branch. The area drained is mountainous and covered with forest growth. The station was established by E. W. Myers in June, 1896. It is located on the Southern Railway bridge, about one-fourth of a mile from Judson, N. C. The standard chain gage with inclosed scale is located on the downstream side of the first span from the left end of the bridge. The length of the chain from the end of the weight to the marker is 26.29 feet. The observer is J. L. Enloe, who reads the gage once daily. The river is straight for several hundred yards above and below the station; the bottom rocky and very rough on the west side and sandy on the east side. The current is swift and considerably obstructed by two wide timber piers. The section is constant, but not a good one for measurements.

Bench mark No. 1 is the top of the angle block on the lower chord at the middle of the first span from the left end of the bridge, on the downstream side. Its elevation is 23.36 feet above gage datum. Bench mark No. 2 is a standard copper bolt set in the rock near the end of the tunnel, on the right bank, 130 feet from the end of the bridge and 8 feet from the center of the track. Its elevation is 28.14 feet above gage datum.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Little Tennessee River at Judson, N. C., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Sq. feet.	*Ft. per sec.*	*Feet.*	*Second-feet.*
March 21	B. S. Drane	434	3.58	3.49	1,554
May 25	do	303	3.27	2.95	993
August 15	do	311	3.07	2.98	955
September 30	do	216	2.02	2.32	436
December 13	do	249	2.33	2.53	580

Mean daily gage height, in feet, of Little Tennessee River at Judson, N. C., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.50	2.65	3.14	3.50	3.25	3.30	2.80	2.75	3.00	2.20	2.10	2.90
2	2.52	2.61	3.08	3.50	3.15	3.20	2.75	2.80	3.10	2.20	2.30	2.80
3	2.48	2.63	2.98	3.55	3.15	3.05	2.55	2.85	2.80	2.20	2.50	2.60
4	2.42	2.48	3.09	3.40	3.20	2.95	2.50	2.75	3.00	2.20	2.60	2.60
5	2.39	2.34	3.13	3.40	3.20	2.85	2.80	2.70	3.20	2.30	2.50	4.10
6	2.43	3.18	4.20	3.35	3.25	2.80	2.60	2.95	2.80	2.20	2.30	3.70
7	2.55	3.30	6.25	3.85	(a)	3.25	2.50	2.75	2.70	2.20	2.20	3.30
8	2.52	3.32	5.15	4.00	(a)	3.30	2.50	3.10	2.70	2.20	2.20	3.70
9	2.48	3.34	4.40	3.90	(a)	3.00	3.25	3.30	2.60	2.20	2.20	3.70
10	2.45	3.28	4.19	3.65	(a)	2.90	2.75	3.20	2.60	2.20	2.20	2.70
11	2.65	3.20	4.65	3.60	(a)	2.90	2.65	4.45	2.60	2.20	2.20	2.60
12	2.58	2.81	4.25	3.60	(a)	2.90	2.65	3.70	2.50	2.20	2.60	2.60
13	2.59	2.81	4.10	3.55	(a)	2.80	2.85	3.45	2.50	2.10	2.60	2.50
14	2.52	3.48	3.90	3.55	3.30	2.75	2.60	3.10	2.50	2.10	2.60	2.50
15	2.45	3.51	3.95	3.50	3.25	2.80	2.50	2.90	2.50	2.10	2.30	2.50
16	3.26	3.22	3.85	3.45	3.20	2.65	2.45	2.85	2.50	2.10	2.30	2.50
17	3.35	3.30	3.85	3.40	3.10	2.65	2.70	2.75	2.40	2.10	2.30	2.55
18	3.22	3.28	3.80	3.35	3.15	2.75	2.80	2.70	2.40	2.10	2.20	2.45
19	3.18	3.30	3.70	3.45	3.15	2.70	2.50	2.65	2.40	2.10	2.20	2.35
20	2.84	3.80	3.65	3.40	3.10	2.90	2.45	2.60	2.40	2.10	2.20	2.10
21	2.58	4.24	3.60	3.35	3.10	2.90	2.50	2.70	2.30	2.10	2.40	2.35
22	5.30	5.38	4.72	3.30	3.05	3.00	3.00	2.65	2.40	2.10	2.60	2.35
23	4.28	4.47	5.66	3.30	2.95	2.80	2.80	2.55	2.40	2.10	2.50	2.50
24	3.22	4.13	5.12	3.25	2.90	2.70	2.70	2.90	2.30	2.10	2.30	2.50
25	3.18	3.91	4.40	3.25	2.90	2.70	2.60	2.80	2.30	2.10	2.30	2.95
26	2.59	3.63	4.10	3.20	2.95	2.80	2.50	3.00	2.30	2.10	2.20	2.80
27	2.50	3.31	3.45	3.20	2.95	2.90	2.65	3.70	2.30	2.10	2.20	2.70
28	2.42	3.14	3.45	3.15	2.90	2.70	2.60	3.50	2.40	2.10	2.60	4.70
29	2.45	3.10	3.40	3.15	2.85	3.20	2.55	2.90	2.40	2.10	2.80	3.70
30	2.81	.....	3.45	3.20	2.90	2.85	2.50	2.65	2.30	2.10	2.50	3.30
31	2.71	.....	3.40	.....	3.50	.....	2.45	2.70	.....	2.10	.....	3.10

a Chain stolen.

Rating table for Little Tennessee River at Judson, N. C., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.2	335	3.4	1,580	4.6	3,580	6.6	8,050
2.3	405	3.5	1,720	4.7	3,780	6.8	8,540
2.4	485	3.6	1,860	4.8	3,980	7.0	9,050
2.5	575	3.7	2,000	4.9	4,180	7.5	10,460
2.6	675	3.8	2,140	5.0	4,380	8.0	12,200
2.7	775	3.9	2,300	5.2	4,820	8.5	14,200
2.8	875	4.0	2,460	5.4	5,260	9.0	16,200
2.9	985	4.1	2,620	5.6	5,700	9.5	18,450
3.0	1,100	4.2	2,800	5.8	6,140	10.0	20,700
3.1	1,220	4.3	2,980	6.0	6,580	11.0	25,500
3.2	1,340	4.4	3,180	6.2	7,070		
3.3	1,460	4.5	3,380	6.4	7,560		

The above table is applicable only for open-channel conditions. It is based upon 37 discharge measurements made during 1896 to 1904. It is well defined between gage heights 2.2 and 5 feet. The table has been extended beyond these limits. Above gage height 10 feet the rating curve is a tangent, the difference being 480 per tenth.

Estimated monthly discharge of Little Tennessee River at Judson, N. C., for 1904.

[Drainage area, 675 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	5,040	477	984	1.46	1.68
February	5,216	437	1,620	2.40	2.[illegible]
March	7,192	1,077	2,617	3.88	4.[illegible]
April	2,460	1,280	1,655	2.45	2.[illegible]
May	1,720	930	1,268	1.88	2.[illegible]
June	1,460	725	992	1.47	1.64
July	1,400	530	724	1.07	1.[illegible]
August	3,280	625	1,112	1.65	1.[illegible]
September	1,340	405	642	.951	1.[illegible]
October	405	275	300	.444	.[illegible]
November	875	275	472	.699	.[illegible]
December	3,780	275	964	1.43	1.[illegible]
The year	7,192	275	1,112	1.65	22.41

TUCKASEGEE RIVER AT BRYSON, N. C.

Tuckasegee River rises in the southwestern part of North Carolina, at the base of Tennessee Ridge, which separates Jackson and Transylvania counties. It flows in a northwesterly direction, emptying into Little Tennessee River at Bushnell, N. C. Measurements of discharge are made at Bryson, 2 miles below the mouth of Newton Mill Creek. The drainage area is largely rough and mountainous and covered with forest growth.

This station was originally established by E. W. Myers, June, 1896, at the Southern Railroad bridge, about 3 miles above Bryson, N. C., just below Governor Island post-office. This station was abandoned March 25, 1897, on account of the poor section. The present station was established November 7, 1897, by A. P. Davis, at the highway bridge in the town of Bryson, N. C., 2 miles below the mouth of Newton Mill Creek. The gage is a vertical rod bolted to the north pier on the right bank at the downstream side of the bridge. It is read once daily by J. M. Welch. Discharge measurements are made from the sidewalk on the downstream side of the single-span steel highway bridge. The initial point for soundings is the end of the hand rail at the left bank on the downstream side of the bridge. The channel is straight for about 600 feet above and below the station. The water is moderately swift, but the current is obstructed by the remnants of two old bridge piers. The right bank is low at the bridge and overflows to a slight extent, but all water passes beneath the bridge and its approach. The right bank is high and rocky and does not overflow. The bed is of gravel and sand and is fairly constant. Bench mark No. 1 is a copper bolt set in the stone sill beneath the large window in the northwest corner of D. K. Collins's brick store, about 80 feet east of the northeast corner of the county court-house. The window is on the side of the store nearest the court-house. The elevation of the bench mark is 22.32 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Tuckasegee River at Bryson, N. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
February 18	B. S. Drane	189	865	0.92	1.31	79
February 20	do	189	937	1.32	1.82	1,23
February 23	M. R. Hall	189	988	1.82	2.04	1,80
March 19	B. S. Drane	188	949	1.35	1.74	1,28
March 22	do	190	1,079	1.92	2.29	2,06
May 26	do	290	882	1.07	1.41	94
August 15	do	187	821	1.14	1.41	94
August 16	do	188	869	1.47	1.65	1,27
September 30	do	182	701	.65	1.00	45
October 1	do	182	701	.60	.98	42
October 12	do	182	730	.75	1.11	55
December 14	do	182	721	.70	1.05	50

Mean daily gage height, in feet, of Tuckasegee River at Bryson, N. C., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.10	1.20	1.85	1.90	1.60	1.70	1.45	1.40	1.30	1.00	0.85	1.1
2	1.20	1.10	1.70	1.80	1.60	1.70	1.35	1.40	1.50	1.00	.85	1.0
3	1.10	1.25	1.70	1.75	1.60	1.60	1.25	1.30	1.30	.95	1.00	1
4	1.00	1.10	1.65	1.70	1.55	1.50	1.40	1.30	1.40	.95	1.10	1
5	.90	1.15	1.50	1.70	1.50	1.40	1.30	1.40	1.50	.95	1.15	2
6	1.10	1.20	1.50	1.80	1.50	1.40	1.25	1.40	1.30	.95	1.05	1
7	1.10	1.90	4.80	2.60	1.50	2.00	1.20	1.80	1.20	.95	.90	1.4
8	1.05	2.00	2.65	2.40	3.90	1.70	1.20	1.40	1.20	.95	.90	1.3
9	1.00	1.60	2.30	2.10	2.60	1.60	1.60	1.40	1.20	.90	.90	1.2
10	1.10	1.50	2.05	1.95	2.10	1.45	1.35	2.00	1.20	.90	.90	1.2
11	1.25	1.50	2.10	1.85	1.90	1.50	1.35	2.00	1.25	.90	.90	1
12	1.10	1.40	1.90	1.80	1.80	1.40	1.30	1.70	1.15	.90	.90	1
13	1.25	1.30	1.80	1.75	1.80	1.35	1.20	1.50	1.15	.90	1.25	1
14	1.10	1.40	1.40	1.70	1.80	1.30	1.25	1.40	1.10	.90	1.10	1.0
15	1.10	1.40	2.00	1.70	1.70	1.30	1.15	1.40	1.10	.90	1.00	1.0
16	1.50	1.30	1.85	1.70	1.60	1.30	1.30	1.50	1.05	.90	.95	1.0
17	1.60	1.25	1.80	1.70	1.60	1.30	1.25	1.30	1.05	.90	.95	1.0
18	1.30	1.30	1.85	1.60	1.55	1.30	1.20	1.30	1.00	.90	.90	1.0
19	1.20	1.70	1.70	1.60	1.55	1.30	1.10	1.25	1.00	.90	.90	1.0
20	1.20	1.60	1.70	1.70	1.50	1.55	1.20	1.30	1.00	.85	.90	.9
21	1.20	2.00	2.10	1.70	1.50	1.30	1.30	1.20	1.00	.90	.90	1.0
22	5.40	2.80	2.10	1.60	1.45	1.50	1.40	1.20	1.00	.85	1.10	.9
23	1.90	2.00	3.70	1.55	1.40	1.30	1.40	1.30	1.00	.85	1.15	1.0
24	1.60	1.80	3.10	1.50	1.40	1.25	1.40	1.70	1.00	.85	1.00	1.2
25	1.60	1.70	2.70	1.50	1.40	1.25	1.40	1.50	1.00	.90	1.00	1.4
26	1.50	1.60	2.70	2.30	1.35	1.40	1.30	1.50	.95	.90	.90	1.3
27	1.35	2.00	2.60	1.80	1.35	1.30	1.20	1.60	.95	.90	.90	2.2
28	1.40	1.70	2.30	1.70	1.30	1.40	1.30	1.40	1.00	.85	.90	2.2
29	1.40	1.70	2.15	1.70	1.40	1.95	1.20	1.30	1.00	.85	.90	1.4
30	1.20	.....	2.10	1.70	1.60	1.50	1.20	1.25	1.00	.85	1.50	1.4
31	1.20	.....	2.00	.....	2.00	.....	1.20	1.25	.....	.85	.....	1.3

Rating table for Tuckasegee River at Bryson, N. C., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.9	380	1.9	1,510	2.9	3,250	3.9	5,540
1.0	460	2.0	1,660	3.0	3,460	4.0	5,800
1.1	550	2.1	1,810	3.1	3,670	4.2	6,350
1.2	650	2.2	1,970	3.2	3,890	4.4	6,920
1.3	750	2.3	2,130	3.3	4,110	4.6	7,530
1.4	860	2.4	2,300	3.4	4,330	4.8	8,160
1.5	980	2.5	2,480	3.5	4,560	5.0	8,800
1.6	1,100	2.6	2,660	3.6	4,800	5.2	9,475
1.7	1,230	2.7	2,850	3.7	5,040	5.4	10,250
1.8	1,370	2.8	3,050	3.8	5,290		

The above table is applicable only for open-channel conditions. It is based principally upon discharge measurements made during 1904. It is well defined.

Estimated monthly discharge of Tuckasegee River at Bryson, N. C., for 1904.

[Drainage area, 662 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	10,250	380	1,026	1.55	1.79
February	3,050	550	1,103	1.67	1.80
March	8,160	860	2,061	3.11	3.58
April	2,660	980	1,378	2.08	2.32
May	5,540	750	1,286	1.94	2.24
June	1,660	700	942	1.42	1.58
July	1,100	550	743	1.12	1.29
August	1,660	650	921	1.39	1.60
September	980	420	586	.885	.986
October	460	340	383	.579	.668
November	980	340	457	.690	.770
December	3,050	420	805	1.22	1.41
The year	10,250	340	974	1.47	20.03

HIWASSEE RIVER AT MURPHY, N. C.

The station was established July 26, 1896, by E. W. Myers. It is located at the highway bridge, about 80 feet above the Atlanta, Knoxville and Northern Railroad bridge and one-half mile above the mouth

of Valley River. The standard chain gage, with 24-inch box, is clamped to the top of the downstream end of the first iron floorbeam from the right bank in the space between the bridge floor and the lower chords. The length of the chain from the bottom of the weight to the index is 27.05 feet. The gage is read once each day by William Mingus. Discharge measurements are made from the sidewalk on the upstream side of the single-span highway bridge. The bridge is 195 feet long, supported by stone abutments. The initial point for soundings is the end of the iron hand rail on the right bank, upstream side of the bridge. The channel is straight for about 500 feet above and below the station. The right bank is high and rocky and will not overflow. The left bank will overflow for a short distance around the abutment. The bed of the stream is rocky and rough and makes soundings uncertain. The bed is permanent and the flow is rapid.

Bench mark No. 1 is the downstream side of the top of the stone pier at the right bank, 22.55 feet above gage datum. Bench mark No. 2 is the top of the downstream end of the first iron floorbeam from the right end of the bridge; its elevation is 25.05 feet above gage datum. Bench mark No. 3 is a cut with large nail on a large white-oak tree in the grounds of the Atlanta, Knoxville and Northern Railroad station, on the left side of the street leading from the highway bridge to the town and 325 feet from the end of the bridge. Its elevation is 31.57 feet above gage datum. Bench mark No. 4 is a copper plug set in the solid rock on the right side of the river, 100 feet from the water's edge, 10 feet uphill from the foot of the hill and 500 feet up the river from the bridge. Its elevation is 21.31 feet above gage datum.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Hiwassee River at Murphy, N. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet*
February 22	M. R. Hall	172	562	3.55	6.63	1,9[illegible]
February 24	do	168	441	2.58	6.00	1,1[illegible]
March 1	O. P. Hall	168	392	1.69	5.54	[illegible]
March 2	do	168	386	1.67	5.54	64[illegible]
May 12	do	168	403	1.87	5.66	75[illegible]
June 29	do	167	366	1.75	5.53	6[illegible]
August 29	do	164	318	1.08	5.10	34[illegible]
October 6	do	156	259	.71	4.80	1[illegible]
December 15	M. R. Hall	162	266	1.08	5.02	[illegible]

Mean daily gage height, in feet, of Hiwassee River at Murphy, N. C., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.90	5.15	5.50	5.75	5.45	5.50	5.25	5.50	5.20	4.80	4.75	5.15
2	4.90	5.10	5.50	5.70	5.40	5.35	5.10	5.20	5.10	4.80	4.75	5.00
3	5.05	5.25	5.55	5.60	5.45	5.30	5.10	5.05	5.05	4.80	4.80	5.55
4	4.95	5.10	5.55	5.55	5.45	5.25	5.05	5.05	5.30	4.80	5.00	5.15
5	4.90	5.10	5.45	5.55	5.50	5.20	5.45	5.05	5.55	4.80	4.95	5.15
6	4.85	5.10	5.40	5.50	5.45	5.15	5.10	5.65	5.15	4.80	4.90	5.95
7	5.00	5.15	7.80	5.95	5.40	6.85	5.10	5.15	5.10	4.80	4.80	5.40
8	4.85	6.00	6.60	6.50	5.55	5.65	5.05	5.85	5.05	4.80	4.80	5.15
9	4.90	5.50	6.15	5.95	5.55	5.35	6.15	5.45	5.00	4.75	4.80	5.10
10	4.90	5.45	5.90	6.05	6.05	5.25	5.25	5.25	5.00	4.75	4.80	5.15
11	4.95	5.40	6.00	5.95	5.80	5.25	5.10	5.65	5.00	4.75	4.80	5.15
12	5.05	5.35	5.75	5.80	5.70	5.35	5.10	5.45	4.95	4.75	4.80	5.00
13	5.05	5.25	5.70	5.70	5.60	5.20	5.25	5.50	4.95	4.75	5.00	5.05
14	5.10	5.20	6.25	5.65	5.55	5.15	5.10	5.25	4.95	4.75	5.00	5.05
15	5.00	5.60	6.00	5.60	5.55	5.15	5.00	7.25	4.95	4.75	5.00	5.00
16	5.00	5.40	5.75	5.65	5.45	5.10	5.00	5.45	4.90	4.75	4.90	5.00
17	5.70	5.30	5.70	5.55	5.45	5.10	5.35	5.25	4.90	4.75	4.80	5.05
18	5.35	5.25	5.65	5.55	5.45	5.10	5.35	5.15	4.90	4.75	4.80	5.05
19	5.20	5.25	5.60	5.50	5.40	5.10	5.00	5.10	4.85	4.75	4.85	5.05
20	5.15	6.05	5.50	5.45	5.35	5.65	4.95	5.45	4.85	4.75	4.85	5.00
21	5.10	5.70	5.50	5.60	5.35	5.30	4.95	5.20	4.95	4.75	4.80	4.95
22	5.20	6.55	6.50	5.45	5.30	5.20	5.20	5.10	4.90	4.75	4.90	4.95
23	6.30	6.40	7.40	5.40	5.30	5.15	5.05	5.10	4.90	4.70	4.90	4.95
24	5.70	6.00	7.35	5.40	5.30	5.10	5.05	5.50	4.85	4.75	4.95	5.00
25	5.45	5.75	6.50	5.40	5.25	5.05	5.15	5.35	4.85	4.75	4.85	5.25
26	5.35	5.60	6.35	5.40	5.25	5.25	5.00	5.10	4.85	4.75	4.85	5.15
27	5.25	5.60	6.35	5.75	5.25	5.60	4.95	5.60	4.85	4.75	4.85	5.10
28	5.20	5.50	6.10	5.60	5.20	5.10	4.95	5.30	4.85	4.80	4.80	6.45
29	5.20	5.45	6.00	5.55	5.20	5.85	5.05	5.15	4.85	4.80	4.80	5.65
30	5.05	.....	5.90	5.50	5.20	5.30	5.20	5.10	4.85	4.80	5.25	5.40
31	5.20	.....	5.80	.....	6.10	.....	4.95	5.10	.....	4.75	.....	5.30

Rating table for Hiwassee River at Murphy, N. C., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
4.8	190	5.6	710	6.4	1,690	7.2	3,130
4.9	235	5.7	800	6.5	1,850	7.3	3,330
5.0	285	5.8	900	6.6	2,020	7.4	3,540
5.1	340	5.9	1,010	6.7	2,190	7.5	3,750
5.2	400	6.0	1,130	6.8	2,370	7.6	3,960
5.3	470	6.1	1,260	6.9	2,550	7.7	4,180
5.4	540	6.2	1,400	7.0	2,740	7.8	4,400
5.5	620	6.3	1,540	7.1	2,930		

The above table is applicable only for open-channel conditions. It is based upon 59 discharge measurements made during 1900 to 1904, inclusive. It is well defined between gage heights 4.8 feet and 6.8 feet. The table has been extended above gage height 6.8 feet. Above gage height 7.6 feet the rating curve is a tangent, the difference being 220 per tenth.

Estimated monthly discharge of Hiwassee River at Murphy, N. C., for 1904.

[Drainage area, 410 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	1,540	212	401	0.978	1.13
February	1,935	340	671	1.64	1.77
March	4,400	540	1,303	3.17	3.66
April	1,850	540	777	1.90	2.12
May	1,260	400	605	1.48	1.71
June	2,460	312	532	1.30	1.45
July	1,330	260	380	.927	1.07
August	3,230	312	573	1.40	1.61
September	665	212	282	.688	.76
October	190	150	176	.429	.495
November	435	170	224	.546	.609
December	1,770	260	438	1.07	1.23
The year	4,400	150	530	1.29	17.62

HIWASSEE RIVER AT RELIANCE, TENN.

This station was established August 17, 1900, by O. P. Hall. It is located at the Atlanta, Knoxville and Northern Railroad bridge, near the ferry landing. The gage consists of a vertical rod, reading from zero to 10 feet, fastened to an oak tree on the right bank, 150 feet above the railroad bridge and 40 feet below the ferry landing, and a 5-foot section, reading from 10 to 15 feet, attached to a sycamore tree on the downstream side of the road leading to the ferry, about 40 feet from the river. The gage is read once each day by C. V. Higdon. Discharge measurements are made from the railroad bridge and from the wooden trestles on both banks. The railroad track is about 34 feet above low water. The initial point for soundings is the center of the heavy bolt or bridge pin, about 1 foot from the end of the bridge on the right bank, downstream side. This point is also at the center of the pier on the right bank. Above the station the channel makes a sharp bend to the east for a distance of 800 feet. Below the station the channel makes a sharp bend to the west for about 1,000 feet. At ordinary stages the river is about 350 feet wide at this point, and the section is a fairly good one. The water is held back by a ledge of rock below and is rather sluggish at low stages. Discharge measurements at low stages can be made at a ferry near Wetmore, 6 miles below. Both banks overflow, but all water passes beneath the bridge and its approaches.

Bench mark No. 1 is a cut in a hickory tree on the right bank of the river, about 75 feet upstream from the bridge. Its elevation is 5.82 feet above the zero of the gage. Bench mark No. 2 is the top of the downstream iron girder under the cross-ties at a point about 40 feet from the end of the bridge on the right bank. Its elevation is 23.90 feet above the zero of the gage. Bench mark No. 3 is the top of the capstone of the right-bank pier on the upstream side of the bridge. Its elevation is 19.26 feet above the zero of the gage. Bench mark No. 4 is a copper plug set in a stone post flush with the surface of the ground at the south end of C. V. Higdon's house, under the south window. This house stands on the right bank, about 50 feet up from the foot of the hill, 600 feet north of the right-bank end of the bridge and opposite a point on the river about 300 feet above the bridge. Its elevation is 27.16 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Hiwassee River at Reliance, Tenn., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
February 24	O. P. Hall	332	2,197	1.45	2.32	3,177
February 25	do	331	2,145	1.23	2.10	2,632
February 25	M. R. Hall	304	2,017	1.36	2.10	2,735
May 16	O. P. Hall	308	1,968	.82	1.64	1,607
August 25	do	302	1,855	.55	1.30	1,012
August 26	do	302	1,864	.53	1.28	994
October 10	do	299	1,656	.25	.75	418

Mean daily gage height, in feet, of Hiwassee River at Reliance, Tenn., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.00	1.30	1.80	2.40	1.65	1.90	1.50	1.10	1.10	0.80	0.75	1.20
2	1.00	1.40	1.80	2.00	1.60	1.60	1.25	1.50	1.20	.75	.75	1.30
3	1.10	1.40	1.70	1.90	1.60	1.45	1.15	1.25	1.05	.80	.75	1.40
4	1.30	1.30	1.70	1.85	1.30	1.45	1.10	1.50	1.00	.80	.85	1.50
5	1.40	1.30	1.70	1.80	1.20	1.40	1.10	1.15	1.45	.80	1.00	1.30
6	1.30	1.20	1.60	1.80	1.60	1.25	1.55	2.50	1.40	.78	1.00	2.10
7	1.40	1.20	2.20	2.00	1.55	1.30	1.20	1.60	1.15	.75	.90	1.70
8	1.10	2.10	3.20	2.10	1.30	1.85	1.15	1.65	1.05	.72	.85	1.60
9	1.10	2.00	2.50	2.80	3.20	1.55	1.10	1.45	1.00	.75	.85	1.30
10	1.00	1.70	2.10	2.30	2.30	1.40	1.40	1.50	.90	.75	.80	1.20
11	1.10	1.60	2.10	2.30	2.05	1.25	1.20	1.60	1.00	.75	.80	1.25
12	1.20	1.60	2.10	2.00	1.90	1.30	1.40	1.60	.95	.75	.80	1.30
13	1.30	1.50	1.90	2.00	1.80	1.35	1.50	1.45	.95	.75	.95	1.15
14	1.30	1.40	2.20	1.85	1.75	1.20	1.30	1.45	.92	.72	1.00	1.17
15	1.30	1.50	2.50	1.80	1.75	1.20	1.10	1.40	.90	.72	1.05	1.20
16	1.20	1.60	2.20	1.85	1.65	1.15	.90	2.10	.90	.72	.90	1.15
17	1.60	1.50	2.00	1.75	1.60	1.15	1.10	1.50	.85	.72	.85	1.10
18	1.80	1.50	1.90	1.75	1.60	1.15	1.12	1.35	.85	.72	.85	1.35
19	1.50	1.60	1.85	1.70	1.55	1.15	1.20	1.35	.80	.70	.85	1.25
20	1.40	2.30	1.80	1.65	1.50	1.15	.90	1.35	.80	.70	.85	1.15
21	1.30	2.00	1.80	1.70	1.50	1.50	.94	1.40	.90	.70	.85	1.05
22	1.70	2.70	3.10	1.70	1.45	1.40	1.40	1.25	.95	.70	.95	1.00
23	3.60	3.10	4.30	1.60	1.40	1.40	1.50	1.25	.85	.70	1.00	1.00
24	2.30	2.50	4.30	1.60	1.40	1.20	1.20	1.10	.90	.70	1.20	1.00
25	1.90	2.10	3.30	1.60	1.40	1.15	1.18	1.35	.80	.70	1.00	1.00
26	1.60	1.90	2.80	1.70	1.35	1.20	1.22	1.30	.80	.70	.90	1.05
27	1.50	1.80	2.80	2.20	1.35	1.30	1.15	1.10	.80	.75	.90	1.10
28	1.40	1.80	2.60	1.85	1.30	1.50	1.10	1.60	.80	.75	.85	2.50
29	1.40	1.80	2.40	1.80	1.30	1.60	1.40	1.30	.85	.75	.85	2.60
30	1.40	.....	2.20	1.75	1.30	1.70	1.15	1.20	.85	.75	1.20	1.70
31	1.30	.....	2.40	.....	1.60	.....	1.15	1.10	.....	.80	.....	1.50

Rating table for Hiwassee River at Reliance, Tenn., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.7	380	1.7	1,725	2.7	4,410	3.7	8,080
.8	460	1.8	1,940	2.8	4,745	3.8	8,475
.9	550	1.9	2,165	2.9	5,090	3.9	8,875
1.0	655	2.0	2,400	3.0	5,445	4.0	9,280
1.1	770	2.1	2,650	3.1	5,805	4.1	9,685
1.2	895	2.2	2,915	3.2	6,170	4.2	10,090
1.3	1,030	2.3	3,190	3.3	6,540	4.3	10,500
1.4	1,180	2.4	3,480	3.4	6,915		
1.5	1,345	2.5	3,780	3.5	7,300		
1.6	1,525	2.6	4,090	3.6	7,690		

The above table is applicable only for open-channel conditions. It is based upon 7 discharge measurements made during 1904 and 1 measurement made in 1901. It is well defined between gage heights 0.7 foot and 2.3 feet.

Estimated monthly discharge of Hiwassee River at Reliance, Tenn., for 1904.

[Drainage area, 1,180 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	7,690	655	1,402	1.19	1.37
February	5,805	895	1,962	1.66	1.79
March	10,500	1,525	3,563	3.02	3.48
April	4,745	1,525	2,217	1.88	2.10
May	6,170	895	1,635	1.39	1.60
June	2,165	833	1,169	.991	1.11
July	1,435	550	930	.788	.908
August	3,780	770	1,280	1.08	1.24
September	1,263	460	625	.530	.591
October	460	380	412	.349	.402
November	895	420	562	.476	.531
December	4,090	655	1,281	1.09	1.26
The year	10,500	380	1,420	1.20	16.38

VALLEY RIVER AT TOMOTLA, N. C.

This station was established June 29, 1904, by M. R. Hall. It is located at a footbridge about 250 feet below a public road ford and 200 yards from Tomotla, N. C., and 5 miles above Murphy, N. C. The gage is a vertical timber 10 feet long, graduated to feet and tenths, fastened to a pine timber which is spiked to the upstream side of a maple tree on the right bank about 50 feet below the ford. It is read once each day by J. T. Hayes. Discharge measurements are made from the single-span footbridge, the floor of which is 10 to 15 feet above low water. The initial point for soundings is the upstream edge of abutment next to the water on the right bank. The channel is straight for about 500 feet above and for 1,000 feet below the station. The current is moderately swift. Both banks are high and rocky, and are not liable to overflow. The bed of the stream is composed of rock, but there is a fairly smooth and permanent section. There is but one channel at all stages. Bench mark No. 1 is a cross on the head of a large spike driven into the downstream side of an elm tree about 10 feet upstream from gage. Its elevation is 8.50 feet above the zero of the gage. Bench mark No. 2 is a cross on a point of rock at a spring on right bank about 50 feet above the foot bridge. Its elevation is 3 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Valley River at Tomotla, N. C., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
May 13	O. P. Hall	58	145	1.42	1.76	206
June 29	do	57	117	.71	1.17	83
August 29	do	55	106	.70	1.12	74
October 6	do	55	88	.36	.80	32

Mean daily gage height, in feet, of Valley River at Tomotla, N. C., for 1904.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.10	1.30	1.10	0.90	0.70	1.70	17	1.00	1.40	0.95	0.80	0.90	1.30
2	1.00	1.10	1.10	.90	.70	1.70	18	1.00	1.30	.95	.80	.90	1.20
3	.95	1.10	1.10	.90	.90	2.40	19	.95	1.20	.95	.75	.90	1.20
4	1.00	1.10	1.10	.90	.90	1.60	20	.95	1.20	.95	.75	1.00	1.50
5	1.20	1.10	1.10	.90	1.00	2.10	21	1.00	1.20	.95	.75	1.00	1.20
6	1.00	1.40	1.10	.90	1.00	2.00	22	1.40	1.20	.90	.75	1.00	1.20
7	1.00	1.10	1.10	.90	.90	1.80	23	1.10	2.00	.90	.75	1.00	1.20
8	1.00	1.40	1.10	.85	.90	1.60	24	1.10	1.40	.90	.75	1.00	1.90
9	1.30	1.20	1.00	.85	.90	1.60	25	1.10	1.30	.90	.75	1.00	1.80
10	1.10	1.20	1.00	.85	.90	1.60	26	1.10	1.30	.90	.75	1.00	1.70
11	1.00	1.20	1.00	.85	.90	1.60	27	1.00	1.30	.90	.75	1.00	2.20
12	1.20	1.10	1.00	.85	1.00	1.50	28	1.20	1.30	.90	.70	1.00	2.80
13	1.00	1.10	1.00	.80	1.00	1.50	29	1.00	1.20	.90	.70	1.00	2.30
14	1.00	1.10	.95	.80	1.00	1.40	30	1.00	1.20	.90	.70	2.30	1.90
15	.95	4.00	.95	.80	.90	1.30	31	1.00	1.10	.....	.70	.....	1.60
16	.95	2.00	.95	.80	.90	1.20							

Rating table for Valley River at Tomotla, N. C., from July 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet*
0.7	22	1.2	88	1.7	192	2.2	327
.8	32	1.3	106	1.8	217	2.3	357
.9	44	1.4	126	1.9	243	2.4	388
1.0	57	1.5	147	2.0	270	2.5	420
1.1	72	1.6	169	2.1	298	2.6	452

The above table is applicable only for open-channel conditions. It is based upon four discharge measurements made during 1904. It is fairly well defined between gage heights 0.70 feet and 1.75 feet. The table has been extended above gage height 1.75 feet to 2.60 feet.

Estimated monthly discharge of Valley River at Tomotla, N. C., for 1904.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
July	126	50	65.6
August	1,000	72	13.3
September	72	44	55.2
October	44	22	32.9
November	357	22	59.5
December	452	88	18.1

NOTTELY RIVER NEAR RANGER, N. C.

This station was established February 16, 1901, by O. P. Hall. It is located at the wooden wagon bridge one-half mile from the railroad station at Ranger, N. C., and one-fourth mile below the Atlanta, Knoxville and Northern Railroad bridge. The vertical gage is a 1-inch by 3-inch pine board in two sections, each 8 feet long, fastened to the left-hand side of the first wooden pier from the right bank. The gage is read once each day by A. D. Kilpatrick. Discharge measurements are made from the wagon bridge, a wooden structure of three spans supported by two wooden piers and two stone abutments; the center span is 55 feet long and the end spans are each 36 feet long. The floor of the bridge is about 20 feet above low water. The initial point for soundings is the inside face of the stone abutment on the right bank. The bridge is at a flat bend in the river, the channel curving slightly above and below the station for 600 feet. The right bank is high, rocky, and is somewhat wooded, and will overflow around the end of the bridge for about 50 feet only. The left bank is low and will overflow for a distance of 700 feet at a gage height of from 15 to 18 feet. The bed of the stream is of gravel and sand and probably shifts considerably. The current is somewhat broken and irregular, caused mostly by the piers. There is a moderate velocity and a depth of from 2 to 5 feet at low stages.

Bench mark No. 1 consists of the heads of large wire nails driven in the top of the downstream end of the wooden cap on the left bent of the wooden pier nearest the right bank of the river. Its elevation is 20.05 feet above the zero of the gage. Bench mark No. 2 is a cut on a maple tree 18 inches in diameter, 25 feet from the upstream side of the bridge on the right bank, 25 feet from the edge of the water. Its elevation is 15 feet above the zero of the gage. Bench mark No. 3 is a cut on red oak tree about 15 inches in diameter on the left bank

of the river, 35 feet from the end of the bridge near the downstream side of the road. Its elevation is 17.27 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Nottely River near Ranger, N. C., in 1904.

Date.	Hydrographer.	Area of section.	Mean velocity.	Gage height.	Discharge
		Sq. feet.	*Ft. per sec.*	*Feet.*	*Second-ft*
March 1	O. P. Hall	236	1.58	3.40	37
May 14	do	240	1.47	3.35	353
August 30	do	198	1.12	2.75	
October 7	do	176	.69	2.30	12
December 16	M. R. Hall	190	.97	2.58	184

Mean daily gage height, in feet, of Nottely River near Ranger, N. C., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.80	3.00	3.40	3.80	3.30	3.30	2.90	3.40	2.70	2.30	2.20	
2	2.80	2.90	3.40	3.70	3.30	3.30	2.70	3.00	2.60	2.30	2.20	
3	2.80	2.90	3.30	3.60	3.30	3.00	2.50	2.80	2.60	2.30	2.20	
4	2.70	3.40	3.30	3.50	3.30	2.90	2.40	2.80	2.70	2.20	2.40	
5	2.70	3.20	3.30	3.40	3.30	2.90	2.40	3.60	4.10	2.20	2.30	
6	2.60	3.00	3.20	3.30	3.20	2.80	2.90	3.00	3.00	2.20	2.30	
7	2.80	3.00	3.30	4.20	3.20	7.30	2.70	2.80	2.80	2.20	2.30	
8	2.70	4.50	5.10	5.60	3.30	4.70	2.70	5.00	2.70	2.20	2.30	
9	2.70	3.60	4.50	5.00	4.60	3.70	3.00	3.50	2.60	2.20	2.30	
10	2.60	3.20	4.00	4.50	3.90	3.00	2.80	3.10	2.50	2.20	2.30	
11	2.60	3.30	4.00	4.00	3.70	2.90	2.60	4.00	2.60	2.20	2.30	
12	2.60	3.30	3.80	3.80	3.40	3.00	3.10	3.80	2.60	2.20	2.30	
13	2.50	3.10	3.30	3.70	3.40	2.90	2.20	3.40	2.50	2.20	2.40	
14	2.50	3.00	4.40	3.60	3.30	2.70	2.70	2.90	2.50	2.20	2.40	
15	2.70	3.30	4.00	3.60	3.30	2.70	2.60	3.90	2.40	2.20	2.40	
16	2.80	3.10	3.70	3.50	3.10	2.70	2.40	3.10	2.30	2.20	2.40	
17	4.00	3.00	3.70	3.40	3.10	2.70	2.60	2.90	2.30	2.20	2.40	
18	3.20	3.00	3.70	3.50	3.10	2.70	2.60	2.70	2.30	2.20	2.30	
19	3.80	3.00	3.60	3.50	3.10	2.60	2.50	2.70	2.30	2.20	2.30	
20	3.00	4.80	3.40	3.50	3.10	2.70	2.40	2.70	2.30	2.20	2.30	
21	3.00	3.80	3.30	3.40	3.00	2.90	2.40	2.70	2.20	2.20	2.30	
22	3.00	5.60	5.40	3.40	3.00	3.00	4.20	2.70	2.20	2.20	2.30	
23	5.00	5.00	6.70	3.40	3.00	2.80	2.80	2.60	2.20	2.20	2.30	
24	4.00	4.30	6.40	3.30	2.90	2.70	2.60	3.50	3.00	2.20	2.20	
25	3.80	3.80	5.20	3.30	3.00	2.70	3.10	2.90	2.60	2.20	2.20	
26	3.40	3.70	5.10	3.80	2.90	2.70	2.80	2.80	2.30	2.20	2.20	
27	3.20	3.60	5.00	3.70	2.90	2.80	2.60	2.70	2.30	2.20	2.20	
28	3.00	3.50	4.50	3.70	2.90	3.20	2.80	3.20	2.30	2.20	2.20	
29	3.00	3.30	4.10	3.40	2.90	4.60	2.60	2.70	2.30	2.20	2.20	
30	3.00	.....	4.00	3.40	5.40	3.20	2.60	2.70	2.30	2.20	3.00	
31	2.80	.....	3.90	.....	3.80	.....	2.60	2.70	.....	2.20	.....	

Rating table for Nottely River near Ranger, N. C., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.2	101	3.1	295	4.0	560	4.9	848
2.3	120	3.2	320	4.1	592	5.0	880
2.4	141	3.3	346	4.2	624	5.2	944
2.5	162	3.4	373	4.3	656	5.4	1,008
2.6	184	3.5	402	4.4	688	5.6	1,072
2.7	206	3.6	432	4.5	720	5.8	1,136
2.8	228	3.7	464	4.6	752	6.0	1,200
2.9	250	3.8	496	4.7	784	7.0	1,520
3.0	272	3.9	528	4.8	816		

The above table is applicable only for open-channel conditions. It is based upon 18 discharge measurements made during 1901 to 1904, inclusive. It is well defined between gage heights 2.25 feet and 3.50 feet. The table has been extended beyond these limits. Above gage height 3.60 feet the rating curve is a tangent, the difference being 32 per tenth.

Estimated monthly discharge of Nottely River near Ranger, N. C., for 1904.

[Drainage area, 272 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	880	162	293	1.08	1.24
February	1,072	250	423	1.56	1.68
March	1,936	320	656	2.41	2.78
April	1,072	346	472	1.74	1.94
May	1,008	250	362	1.33	1.53
June	1,616	184	334	1.23	1.37
July	624	101	210	.772	.890
August	880	184	310	1.14	1.31
September	592	101	174	.640	.714
October	120	101	103	.379	.437
November	272	101	124	.456	.509
December	784	141	264	.971	1.12
The year	1,936	101	310	1.14	15.52

OCOEE RIVER AT M'CAYS, TENN.

This station was established March 21, 1903, by O. P. Hall, and was permanently equipped by M. R. Hall on May 13, 1903. It is located at a suspension footbridge just below McCays's ferry at McCays, Tenn., near the Georgia-Tennessee boundary and one-half mile below the railroad bridge of the Atlanta, Knoxville and Northern Railroad. The gage is in two sections, the inclined section reading from −0.3 to 8.5 feet, and consists of double 2 by 6 inch timbers, spiked and bolted together, set in a trench and held in place by 2 by 6 inch posts driven into the ground and bolted or spiked to the gage. The vertical section, reading from 8 to 18 feet, is attached to the bridge posts on the right bank. Discharge measurements are made from the suspension footbridge, consisting of four wire cables and a plank footway. Its span is about 230 feet and it is 23 feet above the water surface at the end supports and 17 feet above the water surface at the middle. The initial point for soundings is the center of the high bent supporting the bridge on the left bank. The channel is practically straight for about 800 feet above and below the station. The right bank will overflow at about 14 feet gage height for about 500 feet; the left bank will overflow at gage height 12 to 20 feet for about 400 feet. The water is confined to one channel and the bed is probably constant. The current is good and the section is excellent.

Bench mark No. 1 is a cut on a walnut tree on the downstream side of the road, about 50 feet from the left-bank landing of McCays's ferry; its elevation is 12.59 feet above the zero of the gage. Bench mark No. 2 is the head of a large nail in the center of a post at the right-bank end of the footbridge, on the downstream side; its elevation is 16.10 feet above the zero of the gage. This post is an anchor post for the cable of the suspension bridge and may be pulled out of place. Bench mark No. 3 is a copper plug set in solid rock at the outer edge of the side ditch of the railroad bed, about 800 feet west of the railroad station at McCays. It is 11 feet north of the center of the track and is slightly higher than the railroad. Its elevation is 20.98 feet above the zero of the gage.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Ocoee River at McCays, Tenn., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per. sec.*	*Feet.*	*Second-ft.*
February 22	Hoyt and M. R. Hall	155	722	2.30	2.80	1,664
February 25	O. P. Hall	150	504	1.39	1.40	701
February 26	do	150	489	1.37	1.30	669
May 11	do	148	488	1.29	1.33	629
June 30	do	140	400	.96	.82	386
August 26	do	134	369	.96	.65	354
October 10	do	128	303	.71	.30	214

Mean daily gage height, in feet, of Ocoee River at McCays, Tenn., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.60	0.90	1.10	1.50	1.20	1.45	0.75	1.60	0.60	0.30	0.30	0.60
2	.60	.80	1.20	1.50	1.25	1.20	.70	.95	.55	.30	.30	.85
3	.70	.90	1.20	1.40	1.25	1.00	.70	.75	.55	.35	.40	1.05
4	.60	.90	1.20	1.35	1.30	1.00	.65	.75	.55	.35	.50	.60
5	.60	.80	1.00	1.30	1.20	.90	.90	1.00	.70	.30	.50	1.85
6	.60	.80	1.00	1.35	1.10	.90	.80	.95	.60	.30	.40	1.40
7	.70	.80	3.00	1.90	1.10	2.10	.70	1.10	.50	.30	.35	.75
8	.60	1.80	2.00	2.30	1.95	1.20	.75	1.70	.50	.30	.30	.60
9	.60	.90	1.60	2.10	1.80	.90	.90	1.25	.50	.30	.30	.50
10	.60	1.00	1.50	1.70	1.45	.90	.75	1.05	.50	.30	.30	.60
11	.80	1.20	1.60	1.65	1.30	.85	.70	1.45	.45	.30	.30	.55
12	.70	1.00	1.45	1.55	1.25	.90	1.20	1.10	.45	.30	.35	.50
13	.70	.90	1.30	1.50	1.20	.85	1.00	1.20	.45	.30	.55	.50
14	.70	.90	2.35	1.40	1.20	.80	.75	.95	.45	.30	.55	.40
15	.70	1.00	1.35	1.40	1.20	.80	.65	1.00	.40	.25	.50	.45
16	.70	.90	1.40	1.40	1.15	.75	.75	.85	.40	.25	.45	.40
17	1.30	.90	1.30	1.35	1.10	.75	.80	.75	.40	.25	.35	.55
18	1.00	.80	1.30	1.35	1.10	.70	.60	.70	.40	.25	.30	.50
19	.80	.90	1.30	1.30	1.10	.70	.60	.75	.40	.25	.30	.45
20	.70	2.00	1.30	1.25	1.15	.80	.55	.80	.35	.25	.30	.40
21	.70	2.00	2.25	1.30	1.00	.75	.60	.70	.40	.25	.35	.40
22	1.00	2.90	2.25	1.35	1.00	1.20	1.10	.60	.45	.25	.40	.40
23	1.70	2.20	3.60	1.25	1.00	.80	.75	.60	.40	.25	.65	.40
24	1.40	1.70	2.80	1.20	.90	.70	.70	.75	.35	.25	.40	.45
25	1.20	1.40	2.20	1.20	1.00	.65	.90	.70	.35	.25	.40	.75
26	1.10	1.30	1.95	1.35	.95	.70	.85	.70	.35	.30	.30	.60
27	.90	1.30	2.20	1.50	.90	.70	.65	.95	.35	.30	.30	1.50
28	1.00	1.20	1.85	1.35	.90	.70	1.00	.75	.40	.30	.30	2.25
29	.90	1.10	1.70	1.30	.90	1.20	.75	.65	.35	.30	.30	1.05
30	.90	.....	1.60	1.20	.90	.85	.70	.60	.30	.30	.75	.80
31	.80	.....	1.55	.....	2.35	.....	.75	.60	.....	.30	.....	.70

Rating table for Ocoee River at McCays, Tenn., from March 20, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.2	200	1.1	551	2.0	1,080	2.9	1,690
.3	230	1.2	602	2.1	1,145	3.0	1,760
.4	262	1.3	655	2.2	1,210	3.1	1,830
.5	296	1.4	710	2.3	1,275	3.2	1,900
.6	332	1.5	767	2.4	1,340	3.3	1,975
.7	370	1.6	826	2.5	1,410	3.4	2,050
.8	411	1.7	887	2.6	1,480	3.5	2,125
.9	455	1.8	950	2.7	1,550	3.6	2,200
1.0	502	1.9	1,015	2.8	1,620		

The above table is applicable only for open-channel conditions. It is based upon 15 discharge measurements made during 1903 and 1904. It is well defined between gage heights 0.25 feet and 3.4 feet. Above gage height 0.50 feet the rating table is the same as for 1903.

Estimated monthly discharge of Ocoee River at McCays, Tenn., for 1904.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
January	887	332	4[illegible]
February	1,690	411	6[illegible]
March	2,200	502	9[illegible]
April	1,275	602	7[illegible]
May	1,308	455	6[illegible]
June	1,145	351	4[illegible]
July	602	314	4[illegible]
August	887	332	4[illegible]
September	370	230	2[illegible]
October	246	215	2[illegible]
November	370	230	2[illegible]
December	1,242	262	4[illegible]
The year	2,200	215	4[illegible]

FIGHTINGTOWN CREEK AT M'CAYS, TENN.

This station was established as a bench-mark station August 27, 1904, by O. P. Hall. It is located about one-half mile above the mouth of the creek, which flows into Ocoee River about one-half mile below the station on Ocoee River, at McCays, Tenn. Discharge measurements are made by means of a boat or by wading. Both banks are open.

cultivated lands, which will probably overflow. The bed is sandy and will no doubt change much. The bench mark is two small nails driven into the largest of a cluster of small maple sprouts on the right bank, 40 feet above the mouth of a small branch. Its elevation is 5 feet above gage datum.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Fightingtown Creek at McCays, Tenn., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
May 12	O. P. Hall	40	119	1.03	[a] 1.25	122
August 27	do	40	107	.74	1.72	79
October 11	do	40	91	.44	1.12	40

[a] Gage height given is for the Ocoee River at McCays.

PAINT ROCK RIVER NEAR PAINTROCK, ALA.

This station was established as a bench-mark station February 4, 1904, by J. M. Giles. It is located at the highway bridge 2¾ miles south of Paintrock, Ala., and about 400 feet above the Southern Railway bridge. Discharge measurements are made from the upstream side of the single-span bridge, which is supported by tubular iron piers and has an approach of 12 feet at the right and 23 feet at the left bank. The initial point for soundings is the center of the upstream pier at the left bank. The channel is straight for about 200 feet above and 600 feet below the station. The current is sluggish. The right bank is low, wooded, and overflows during high water from one-fourth to one-half mile. The left bank is rocky, wooded, and overflows only under the approach. The bed of the stream is rocky, free from vegetation, and permanent. An old crib divides the stream into two channels at low stages. At high stages it is broken by the tubular steel piers. The bench mark is a point on the upstream end of the crossbeam 17 feet from the initial point for soundings. Its elevation is 20 feet above gage datum.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Paint Rock River near Paintrock, Ala., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
February 4	J. M. Giles	62	283	0.56	1.55	159
April 20	do	64	300	.92	2.00	275

FLINT RIVER AT BROWNSBORO, ALA.

This station was established as a bench-mark station February 5, 1904, by J. M. Giles. It is located at the highway bridge about one-fourth mile west of Brownsboro, Ala., and 100 feet below a 6-foot mill-dam. Discharge measurements are made from the downstream side of the single-span bridge, which is supported by tubular iron piers and has a trestle approach of 64 feet at each bank. The initial point for soundings is the center of the downstream pier at the left bank. The channel is straight for about 100 feet above and slightly curved for 500 feet below the station. The current is sluggish above and swift below the section. Both banks are high and clean. The left bank overflows during flood stages, forming a second channel about 500 feet east of the bridge. The bed of the stream is composed of clean sand and gravel, and is permanent. There is one channel at low and two at high stages. The channel at low and intermediate stages is broken by the piers and trestlework of the bridge. The bench mark is the top of the upstream pier at the left bank. Its elevation is 17 feet above gage datum.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Flint River at Brownsboro, Ala., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
February 5	J. M. Giles	120	395	0.53	1.70	209
April 29	do	127	411	.72	1.95	294

ELK RIVER NEAR ELKMONT, ALA.

This station was established June 24, 1904, by M. R. Hall. It is located at the wagon bridge near Wilson's store, about 5 miles east of Elkmont, Ala., and 3 miles below the bridge of the Louisville and Nashville Railway. A standard chain gage of the 24-inch boxed pattern is used. The box and scale are attached to the upstream lattice iron fencing of the bridge, about 125 feet from the right end. The length of the chain from the end of the weight to the marker is 36.45 feet. The gage is read once each day by J. S. Wilson. Discharge measurements are made from the downstream side of the bridge to which the gage is attached. This bridge is of iron, with stone abutments and cylindrical iron piers, having a span of 82 feet at the right bank, a main span of 181 feet, and two spans of 82 and 20 feet, respectively, at the left bank. The initial point for soundings is the end of

the bridge downstream side at the right bank. Distances from the initial point are marked on the rail with white paint. The channel is nearly straight for about 1,500 feet above and straight for about 2,500 feet below the station. The current is swift. Both banks are high, cultivated, and liable to overflow. The bed of the stream is composed of rock, and is permanent. There is one channel broken by two piers at ordinary stage. Bench mark No. 1 is a point marked with white paint on the top of the downstream pier at the right bank. Its elevation is 31 feet above the datum of the gage. Bench mark No. 2 is a chisel mark on the intermediate post at the end of the gage box. Its elevation is 35 feet above gage datum. Bench mark No. 3 is a copper plug set in the upstream corner of the right abutment.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Elk River near Elkmont, Ala., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
April 21	J. M. Giles	213	605	2.23	2.62	1,352
May 17	do	205	482	1.65	2.15	794
June 24	do	170	498	1.39	2.02	690
August 17	do	221	518	1.53	2.10	795
October 20	do	188	335	.60	1.28	202
October 20	do	188	331	.59	1.27	194

Mean daily gage height, in feet, of Elk River near Elkmont, Ala., for 1904.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.30	1.60	1.40	1.30	1.30	1.70	17	1.70	2.10	1.30	1.30	1.30	1.90
2	2.00	2.10	1.30	1.40	1.20	1.70	18	2.00	2.10	1.30	1.20	1.30	1.90
3	1.90	1.90	1.40	1.40	1.30	1.70	19	1.70	1.90	1.20	1.30	1.30	1.90
4	1.80	1.60	2.00	1.40	1.30	2.00	20	2.10	2.30	1.40	1.30	1.30	1.90
5	1.80	2.00	1.40	1.30	1.50	2.40	21	2.40	1.90	1.50	1.30	1.40	1.80
6	2.10	1.70	1.60	2.20	1.60	2.80	22	2.70	1.70	1.40	1.30	1.40	1.80
7	2.30	1.60	1.50	2.00	1.50	3.10	23	2.70	2.50	1.40	1.30	1.40	1.70
8	2.30	1.60	1.30	1.70	1.50	2.90	24	2.20	2.80	1.40	1.20	1.40	1.90
9	2.40	1.60	1.40	1.50	1.40	2.60	25	1.80	2.00	1.40	1.30	1.50	4.80
10	2.10	1.70	1.40	1.40	1.40	2.40	26	1.80	1.80	1.50	1.30	1.40	3.40
11	1.90	6.00	1.40	1.40	1.40	2.40	27	1.70	1.70	1.50	1.20	1.40	6.80
12	2.10	4.10	1.30	1.40	1.30	2.30	28	1.70	1.60	1.50	1.20	1.40	11.70
13	2.00	2.70	1.40	1.30	1.40	2.10	29	1.70	1.50	1.40	1.30	1.40	6.80
14	1.90	2.30	1.30	1.30	1.40	2.10	30	1.80	1.50	1.40	1.20	1.60	5.45
15	1.80	2.70	1.30	1.30	1.30	2.00	31	1.70	1.50	.....	1.20	.....	4.40
16	1.70	2.20	1.30	1.30	1.30	1.90							

Rating table for Elk River near Elkmont, Ala., from July 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.2	165	1.7	468	2.2	870	2.7	1,475
1.3	220	1.8	538	2.3	975	2.8	1,620
1.4	278	1.9	612	2.4	1,090	2.9	1,775
1.5	338	2.0	690	2.5	1,210	3.0	1,940
1.6	401	2.1	775	2.6	1,340		

The above table is applicable only for open-channel conditions. It is based upon six discharge measurements made during 1904. It is well defined between gage heights 1.2 feet and 2.6 feet. The table has been extended above gage height 2.6 feet.

Estimated monthly discharge of Elk River near Elkmont, Ala.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
July	1,475	468	724
August	11,000	338	1,144
September	690	165	287
October	870	165	268
November	401	165	271
December, 1–24	2,115	468	869

BIG SPRING AT TUSCUMBIA, ALA.

This station was established as a bench mark-station July 20, 1903, by M. R. Hall. It is located at the ford just below the spring at Tuscumbia, Ala. Discharge measurements are made by wading, or from a buggy, at the lower side of the ford. There is no fixed initial point for soundings. The channel is nearly straight for about 1,000 feet below the station. The current is swift. Both banks are low and clean. The bed of the stream is composed of sand and gravel, with some moss on the bottom. The bench mark is the top of the fourth stone step from the top, left side, of the steps leading down to the spring. Its elevation is 8 feet above the datum.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Big Spring at Tuscumbia, Ala., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-ft.*
April 22	J. M. Giles	46	70	1.43	2.15	100
August 15	do	45	48	.90	1.55	43
October 19	do	18	13.2	1.50	.70	20
October 19	do	16	12.4	1:50	.70	19

DUCK RIVER AT COLUMBIA, TENN.

This is an old Weather Bureau station which has not been maintained continuously. Two discharge measurements were made in 1901 by M. R. Hall. During 1904 discharge measurements have been made, and the gage heights have been regularly recorded since October 21, 1904.

It is located at the highway bridge two blocks north of the public square at Columbia, Tenn., three-fourths mile below a mill dam. Gage readings are made from the United States Weather Bureau gage, which is a vertical oak timber bolted to the downstream pier at the right bank. The gage reads by feet and tenths from 1 foot to 38 feet. A supplementary gage, graduated from —0.5 to 5 feet is spiked to a small willow tree on the left bank about 150 feet above the bridge. The gage is read twice each day by W. O. Cherry. Discharge measurements are made from the downstream side of the two-span bridge to which the gage is attached. The bridge consists of two spans, 199 feet and 97 feet long. Low-water measurements are made from a boat about one-fourth mile above the bridge. The initial point for soundings is the end of the bridge on the left bank, downstream side. The channel is curved for about 1,000 feet above and nearly straight for 2,000 feet below the station. The current is sluggish above and swift below the measuring section. Both banks are high and fringed with trees. The right bank overflows under the short span of the bridge during floods. The bed of the stream is composed of rock and gravel, free from vegetation and constant. There is one channel; all water passing under the left span at ordinary and under both spans at high stages.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Duck River at Columbia, Tenn., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Ft. per sec.*	*Feet.*	*Second-feet.*
May 21	J. M. Giles	85	610	0.49	0.70	299
August 18	do	115	755	.38	.70	287
August 18	do	115	725	.39	.70	284
October 21	do	79	139	.94	.44	130
October 21	do	79	144	1.10	.40	158

Mean daily gage height, in feet, of Duck River at Columbia, Tenn., in 1904.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1	.....	0.40	0.40	12	.....	0.45	0.75	23	0.45	0.40	0.45
2	.....	.35	.35	13	.....	.45	.60	24	.50	.35	1.50
3	.....	.30	.45	14	.....	.45	.55	25	.45	.45	4.0
4	.....	.40	.50	15	.....	.50	.65	26	.40	.45	4.80
5	.....	.55	.70	16	.....	.35	.70	27	.40	.40	16.45
6	.....	.50	1.35	17	.....	.35	.55	28	.40	.45	15.25
7	.....	.70	2.40	18	.....	.35	.55	29	.40	.40	8.55
8	.....	.60	1.60	19	.....	.35	.55	30	.30	.40	4.45
9	.....	.50	1.00	20	.....	.30	.50	31	.40	.....	3.70
10	.....	.45	.95	21	0.45	.40	.50				
11	.....	.45	.85	22	.50	.40	.50				

MISCELLANEOUS DISCHARGE MEASUREMENTS IN THE TENNESSEE RIVER DRAINAGE BASIN.

The following is a list of miscellaneous discharge measurements made in the Tennessee River drainage basin during 1904:

Roane Creek at Butler, Tenn.—This stream is an important tributary of Watauga River. A measurement was made March 26 at the county bridge crossing the creek about 600 feet above its mouth. The bench mark is the top of the downstream end of the second floor beam from the left bank, 25 feet above the datum of the gage.

Width, 82 feet; area, 188 square feet; mean velocity, 2.57 feet per second; gage height, 1.75 feet; discharge, 483 second-feet.

Watauga River at Watauga, Tenn.—A measurement was made July 13 from a bridge. The bench mark is the top of cross brace at the foot of the third post from the left end of the bridge, upstream side, 35 feet above the datum of the gage.

Width, 170 feet; area, 871 square feet; mean velocity, 0.68 foot per second; gage height, 2.70 feet; discharge, 594 second-feet.

Holston River (South Fork) near Bluff City, Tenn.—A measurement was made April 29 at the upper bridge, 9 miles above Bluff City, Tenn. The water surface was 23.10 feet below the bench mark.

Width, 182 feet; area, 632 square feet; mean velocity, 4.92 feet per second; discharge, 3,110 second-feet.

French Broad River at Alexander, N. C.—A measurement was made May 20 from the wagon bridge. The bench mark is the upper edge of the third band from the top on the upstream, left bank tubular pier, 5 feet above the datum of the gage.

Width, 223 feet; area, 992 square feet; mean velocity, 1.34 feet per second; gage height, 1.60 feet; discharge, 1,329 second-feet.

Pigeon River near Newport, Tenn.—Measurements were made at Deep Ford Bridge, 2 miles below Newport, Tenn., and 3 miles below the regular gaging station on Pigeon River, and 1½ miles above the mouth of the river.

March 29: Width, 198 feet; area, 913 square feet; mean velocity, 1.85 feet per second; gage height, 2.35 feet; discharge, 1,694 second-feet.

April 26: Width, 198 feet; area, 854 square feet; mean velocity, 1.07 feet per second; gage height, 1.68 feet; discharge, 915 second-feet.

July 8: Width, 179 feet; area, 768 square feet; mean velocity, 0.74 foot per second; gage height, 1.27 feet; discharge, 574 second-feet.

Clinch River at Clinton, Tenn.—A measurement was made August 8 from the ferryboat, 1,000 feet below the Southern Railway crossing at Clinton, Tenn. The gage height is from the gage of the United States Weather Bureau.

Width, 240 feet; area, 1,813 square feet; mean velocity, 0.61 foot per second; gage height, 3.90 feet; discharge, 1,109 second-feet.

Little Tennessee River at Franklin, N. C.—A measurement was made May 24 from the iron wagon bridge one-half mile east of Franklin, N. C., and 1 mile below the mouth of Cullasagee River. The bench mark is the upper edge of tie plate on the streamward side of the bottom of the first post from the right bank, 20 feet above the datum of the gage.

Gage height, 1.67 feet; discharge, 562 second-feet.

Little Tennessee River near Franklin, N. C.—A measurement was made May 24 from Iotla Bridge, 4 miles north of Franklin, N. C. The bench mark is the top of small plate tying the bottom of first post from the right bank to its floor beam, 22 feet above the datum of the gage.

Width, 131 feet; area, 271 square feet; mean velocity, 2.04 feet per second; gage height, 1.96 feet; discharge, 553 second-feet.

Nantahala River near Nantahala, N. C.—This stream is an important tributary of Little Tennessee River. A measurement was made October 8 from Matthew Cole's foot bridge, about 1 mile above Nantahala, N. C. The bench mark is the top of the left bent on the upstream side, 12 feet above the datum of the gage.

Width, 50 feet; area, 120 square feet; mean velocity, 0.96 foot per second; gage height, 0.82 foot; discharge, 115 second-feet.

Brasstown Creek at Brasstown, N. C.—This stream enters Hiwassee River about 5 miles above Murphy, N. C. A measurement was made May 13, at which time the gage on Hiwassee River at Murphy read 5.60 feet.

Width, 35 feet; area, 61 square feet; mean velocity, 1.34 feet per second; discharge, 82 second-feet.

Hanging Dog Creek near Murphy, N. C.—This creek enters Hiwassee River about 2 miles below Murphy. A measurement was made May 14, at which time the gage on Hiwassee River at Murphy read 5.60 feet.

Width, 33 feet; area, 54 square feet; mean velocity, 1.26 feet per second; discharge, 68 second-feet.

Sequatchie River near Jasper, Tenn.—This stream enters Tennessee River 5 miles south of Jasper, Tenn. A measurement was made February 9 from the highway bridge 2 miles northeast of Jasper, Tenn. The bench mark is the top of the downstream end of crossbeam 37 feet from the center of the right bank pier, 28 feet above the datum of the gage.

Width, 134 feet; area, 790 square feet; mean velocity, 2.32 feet per second; gage height, 8.30 feet; discharge, 1,829 second-feet.

Sequatchie River near Jasper, Tenn.—A measurement was made February 9 from the wagon bridge at Pregor's mill, 2 miles east of Jasper, Tenn. The bench mark is the top of the downstream end of crossbeam 37 feet from the left bank abutment, 28 feet above the datum of the gage.

Width, 170 feet; area, 1,036 square feet; mean velocity, 1.85 feet per second; gage height, 9.95 feet; discharge, 1,916 second-feet.

Battle Creek near South Pittsburg, Tenn.—This stream enters Tennessee River 1 mile east of Jasper, 1½ miles north of the Tennessee-Alabama State line. A measurement was made February 9 from the highway bridge on the road from South Pittsburg to Jasper. The bench mark is the top of the upstream end of crossbeam 56 feet from the right abutment, 25 feet above the datum of the gage.

Width, 67 feet; area, 276 square feet; mean velocity, 1.75 feet per second; gage height, 5.67 feet; discharge, 482 second-feet.

Toccoa River near Blueridge, Ga.—This stream is a tributary of Hiwassee River, its name becoming Ocoee River in the State of Tennessee. A measurement was made October 3 from a small boat, at Bench Leg Ford, 1 mile below the Morganton road bridge, and one-fourth mile below the mouth of Weaver Creek.

Width, 110 feet; area, 264 square feet; mean velocity, 0.65 foot per second; discharge, 172 second-feet.

Fightingtown Creek near Blueridge, Ga.—This stream is a tributary of Toccoa River. A measurement was made October 4 at the Galloway bridge, above the Horseshoe Bend.

Width, 33 feet; area, 25 square feet; mean velocity, 1 foot per second; discharge, 25 second-feet.

Flint River near New Decatur, Ala.—This stream enters Tennessee River from the south, near Decatur, Ala. A measurement was made May 16 from the bridge near New Decatur. The bench mark is the top of the downstream end of the crossbeam 67 feet from the left end of the bridge, 22 feet above the datum of the gage.

Width, 63 feet; area, 138 square feet; mean velocity, 0.45 foot per second; gage height, 2.45 feet; discharge, 62 second-feet.

Elk River near Prospect, Tenn.—This stream is an important tributary of Tennessee River, entering from the northeast, about 20 miles below Decatur, Ala. A measurement was made February 8 from the Louisville and Nashville Railroad bridge, three-fourths of a mile south of Prospect, Tenn. The bench mark is the base of rail, 150 feet from the right end of the bridge, 40 feet above the datum of the gage.

Width, 310 feet; area, 1,772 square feet; mean velocity, 2.99 feet per second; gage height, 2.70 feet; discharge, 5,296 second-feet.

Spring Creek at Tuscumbia, Ala.—This stream enters Tennessee River from the south near Tuscumbia, Ala. A measurement was made February 6 at the wagon bridge one-half mile northwest of the depot at Tuscumbia. The bench mark is the top of the upstream end of the crossbeam 18 feet from the right end of iron bridge, 20 feet above the datum of the gage.

Width, 70 feet; area, 201 square feet; mean velocity, 0.21 foot per second; gage height, 1.47 feet; discharge, 43 second-feet.

Big Bear Creek near Iuka, Miss.—This stream enters Tennessee River from the south, near the Alabama-Mississippi State line, about 5 miles northeast of Iuka. A measurement was made April 22 at the highway bridge, 5 miles east of Iuka. The bench mark is the top of the downstream right bank pier, 30 feet above the datum of the gage.

Width, 160 feet; area, 1,383 square feet; mean velocity, 0.48 foot per second; gage height, 7.10 feet; discharge, 670 second-feet.

YAZOO RIVER DRAINAGE BASIN.

Yazoo River rises in the northwestern part of Mississippi. It flows south just west of the central portion of the State and enters Mississippi River just above Vicksburg. The United States Geological Survey is maintaining a station on this river at Yazoo City, under the direction of M. R. Hall.

YAZOO RIVER AT YAZOO CITY, MISS.

A gage has been maintained at this point by the Engineer Corps of the Army. It was replaced in 1901 by a new gage rod in three sections, marked with brass figures and brass tacks, the sections being placed as follows: The lowest, marked from −3 to +4.5 feet, is attached to the protecting work of the bridge; the middle section, marked from 4.5 to 18.5 feet, is attached to the piling that protects the bridge pier; the uppermost section, continuing the graduation up to 32.3 feet, is on a post under the approach to the bridge. The highest known water occurred in 1882, reaching a gage height of 36.5 feet; the lowest occurred on October 15 to 17 and 20 to 22, 1896, with a gage height of −2.8 feet. The danger line is at 25 feet.

Discharge measurements are made from the highway bridge, consisting of one span of 85 feet, a turn-span of 190 feet, an approach on the right bank of about 100 feet, and on the left bank of about 1,200 feet. This is the bridge to which the gage is attached, and is located one-half mile northwest from the Illinois Central Railroad station in Yazoo City. The initial point for soundings is the end of the iron bridge on the left bank, downstream side. The channel is straight for about 3,000 feet above the station and is curved for about 2,000 feet below. The current is moderately rapid. As this stream is connected with the Mississippi River both above and below the station, it is influenced by the stage of that stream to the extent that high-water measurements are of no value. The bed is of sand and mud, and is subject to some change. The right bank is high, but overflows for a long distance at extreme floods; the left bank is high and overflows to the foot of the hill, about one-half mile from the river. There are trees along both banks.

A bench mark was established on the top of the upstream cylinder of the second pier from the left bank, at a distance of 85 feet from the initial point for soundings, which is on the downstream end of iron bridge on the left bank. The elevation of the mark is 35.85 feet above the zero of the gage. Other important bench marks in Yazoo City are the following: P. B. M. 12, Yazoo City, is a copper bolt in stone under ground, surmounted by an iron pipe and cap, in the north corner of the county court-house yard. It is 44.1 feet above the zero of the gage and 116.2 feet above mean sea level. P. B. M. 13, Yazoo City, is a copper bolt in stone under ground, surmounted by an iron pipe and cap, in the north corner of the public school yard, near Washington and Main streets. It is 29.2 feet above the zero of the gage and 101.3 feet above mean sea level. The observer is P. C. Battaille. Daily gage heights are furnished by the Weather Bureau.

The observations at this station during 1904 have been made under the direction of M. R. Hall, district hydrographer.

Discharge measurements of Yazoo River at Yazoo City, Miss., in 1904.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq. feet.*	*Feet per sec.*	*Feet.*	*Second-ft.*
January 14	J. M. Giles	191	2,043	1.11	−0.55	2,261
August 11	do	223	2,929	1.73	3.00	5,054
October 27	do	183	1,656	.68	−3.15	1,122
October 27	do	183	1,639	.68	−3.15	1,120

Mean daily gage height, in feet, of Yazoo River at Yazoo City, Miss., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.50	3.50	0.00	15.40	22.30	5.50	10.70	6.00	−1.90	−2.80	−2.80	−2.50
2	2.50	3.70	.00	15.80	22.00	4.20	10.00	5.40	−1.90	−2.70	−2.80	−2.30
3	2.50	3.90	.00	16.20	21.80	3.00	9.50	4.00	−1.50	−2.60	−2.80	−2.00
4	2.50	4.00	.00	16.50	21.40	2.00	8.80	3.00	−1.30	−2.60	−2.80	−2.20
5	1.50	4.00	.00	16.80	21.00	1.40	8.30	2.50	−1.50	−2.60	−2.80	−2.20
6	1.00	4.00	.80	17.20	20.50	1.00	7.50	2.00	−1.70	−2.60	−2.80	−2.30
7	.90	4.00	1.40	17.60	20.00	1.00	7.00	1.90	−1.70	−2.60	−2.80	−2.40
8	.70	3.60	1.70	18.70	19.60	1.00	6.50	1.90	−1.90	−2.50	−2.80	−2.40
9	.50	3.40	2.00	18.70	19.00	2.00	6.40	2.00	−2.00	−2.60	−2.80	−2.40
10	.30	3.20	2.30	18.90	18.70	4.00	6.30	2.80	−2.00	−2.70	−2.80	−2.30
11	.00	3.00	2.60	19 10	18.30	5.50	6.00	3.00	−2.00	−2.70	−2.80	−2.20
12	− .30	2.50	2.90	19.40	18.00	6.80	6.30	3.40	−2.00	−2.70	−2.80	−2.00
13	− .50	1.50	3.20	19.80	17.80	7.90	5.80	3.70	−2.00	−2.80	−2.80	−1.90
14	− .60	1.00	3.30	20.00	17.70	8.80	5.50	4.10	−2.00	−2.80	−2.80	−1.80
15	− .60	.70	3.50	20.30	17.50	9.50	5.30	4.30	−2.10	−2.80	−2.80	−1.80
16	− .70	.50	3.80	20.60	17.40	10.30	5.40	4.20	−2.20	−2.80	−3.00	−1.80
17	− .80	.20	4.20	20.80	17.40	10.80	5.50	3.80	−2.20	−2.80	−3.00	−1.80
18	− .90	.00	5.30	21.10	17.30	11.30	6.20	3.50	−2.20	−2.80	−3.00	−1.80
19	−1.00	− .10	6.20	21.40	17.20	11.70	6.80	2.50	−2.20	−2.80	−3.00	−1.90
20	−1.10	− .10	7.00	21.60	17.00	12.00	7.50	2.00	−2.20	−2.80	−3.00	−1.80
21	−1.10	− .10	8.40	21.90	17.00	12.10	8.00	1.60	−2.30	−2.80	−3.00	−2.00
22	−1.10	− .10	9.10	22.00	16.50	12.30	8.30	1.00	−2.40	−2.80	−2.80	−2.10
23	− .10	− .10	9.90	22.20	16.10	12.50	8.50	.50	−2.40	−2.80	−2.80	−2.20
24	.00	− .10	10.80	22.40	15.60	12.40	8.70	− .10	−2.50	−2.80	−2.80	−2.20
25	.20	− .10	11.60	22.50	14.90	12.30	8.80	− .30	−2.60	−2.80	−2.80	−2.20
26	1.00	− .10	12.30	22.60	14.00	12.20	8.80	− .50	−2.70	−2.80	−3.00	−2.40
27	1.80	.00	14.00	22.60	12.90	12.00	8.80	− .80	−2.80	−2.80	−3.00	3.80
28	2.50	.00	14.10	22.60	11.50	12.00	8.80	−1.20	−2.80	−2.80	−3.00	4.20
29	3.00	.00	14.30	22.60	10.00	11.50	8.00	−1.40	−2.80	−2.80	−3.00	5.40
30	3.40	.....	14.70	22.50	8.50	11.30	7.50	−1.50	−2.80	−2.80	−3.00	7.50
31	3.50	.....	15.00	.....	7.00	.....	6.60	−1.80	.....	−2.80	.....	9.00

Rating table for Yazoo River at Yazoo City, Miss., from August 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
—3.0	1,190	—2.2	1,534	—1.4	1,884	—0.6	2,239
—2.9	1,233	—2.1	1,577	—1.3	1,928	—0.5	2,284
—2.8	1,276	—2.0	1,620	—1.2	1,972	—0.4	2,329
—2.7	1,319	—1.9	1,664	—1.1	2,016	—0.3	2,374
—2.6	1,362	—1.8	1,708	—1.0	2,060	—0.2	2,419
—2.5	1,405	—1.7	1,752	—0.9	2,104	—0.1	2,464
—2.4	1,448	—1.6	1,796	—0.8	2,149	0.0	2,510
—2.3	1,491	—1.5	1,840	—0.7	2,194		

The above table is based upon 13 discharge measurements made during 1901 to 1904, and is well defined.

Estimated monthly discharge of Yazoo River at Yazoo City, Miss., for 1904.

[Drainage area, 8,580 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	4,245	2,016	2,856	0.333	0.384
February	4,520	2,464	3,294	.384	.414
August	5,800	1,708	3,516	.410	.473
September	1,928	1,276	1,555	.181	.202
October	1,405	1,276	1,302	.152	.175
November	1,276	1,190	1,244	.145	.162
December	8,220	1,405	2,273	.265	.306

Estimates March to July omitted, on account of probable back-water influence of Mississippi River on this station during portions of those months.

INDEX.

Alderson, W. Va. Page.
  Greenbrier River at:
    description 70–71
    discharge 71
    discharge, monthly 73
    gage heights 72
    rating table 72
Alexander, N. C.
  French Broad River at:
    description 155
    discharge 155
Allegheny River at—
  Kittanning, Pa.:
    description 47
    discharge 47
    gage heights 47
  Redhouse, N. Y.:
    description 45–46
    discharge 46
    gage heights 46
Allegheny River drainage basin:
  description 44–45
Ashville, N. C.
  French Broad River near:
    description 99–100, 100–101
    discharge 100–101
Avery Creek at—
  Davisons River, N. C.:
    description 110–111
    discharge 111
Battle Creek near—
  South Pittsburg, Tenn.:
    description 156
    discharge 156
Big Bear Creek near—
  Iuka, Miss.:
    description 157
    discharge 157
Big Spring at—
  Tuscumbia, Ala.:
    description 152
    discharge 153
Biltmore, N. C.
  Swannanoa River at:
    description 104
    discharge 104
Blacklick, Pa.
  Blacklick Creek at:
    description 50–51
    discharge 51
    gage heights 51
Blacklick Creek at—
  Blacklick, Pa.:
    description 50–51
    discharge 51
    gage heights 51
Blueridge, Ga. Page.
  Fightingtown Creek near:
    description 157
    discharge 157
  Toccoa River near:
    description 156
    discharge 156
Bluff City, Tenn.
  Holston River (South Fork) at and near:
    description 122, 154
    discharge 122, 155
    discharge, monthly 124
    gage heights 123
    rating table 123
Brasstown, N. C.
  Brasstown Creek at:
    description 156
    discharge 156
Brasstown Creek at—
  Brasstown, N. C.:
    description 156
    discharge 156
Brownsboro, Ala.
  Flint River at:
    description 150
    discharge 150
Bryson, N. C.
  Tuckasegee River at:
    description 133
    discharge 134
    discharge, monthly 135
    gage heights 134
    rating table 135
Butler, Tenn.
  Roane Creek at:
    description 154
    discharge 154
Calhoun, N. C.
  Little River at:
    description 111
    discharge 111
Casselman River at—
  Confluence, Pa.:
    description 57–58
    discharge 58
    gage heights 58
Cataract, Ind.
  Eel River (lower) at:
    description 91–92
    gage heights 92
Chadakoin River at—
  Jamestown, N. Y.:
    description 48
    discharge 48
    gage heights 49

Channahon, Ill. Page.
Desplaines River near:
description 40–41
discharge..... 41
discharge, monthly 43
gage heights..... 42
rating table 43
Chattanooga, Tenn.
Tennessee River at:
description 107–108
discharge..... 108
gage heights..... 108
Cheat River near—
Morgantown, W. Va.:
description 52
discharge..... 53
gage heights..... 53
Chippewa River near—
Eau Claire, Wis.:
description 20
discharge..... 21
discharge, monthly..... 22
gage heights..... 21
rating table 22
Chippewa River drainage basin:
description 20
Clinch River at—
Clinton, Tenn.:
description 155
discharge..... 155
Clinton, Tenn.
Clinch River at:
description 155
discharge..... 155
Columbia, Tenn.
Duck River at:
description 153
discharge..... 154
gage heights..... 154
Columbus, Ohio.
Olentangy River near:
description 77
discharge..... 77
discharge, monthly..... 79
gage heights..... 78
rating tables..... 78–79
Scioto River near:
description 74
discharge..... 75
discharge, monthly..... 76
gage heights..... 75
rating table 76
Confluence, Pa.
Casselman River at:
description 57–58
discharge..... 58
gage heights..... 58
Laurel Hill Creek at:
description 58–59
discharge..... 59
gage heights..... 59
Youghiogheny River near:
description 56
discharge..... 57
gage heights..... 57

Cumberland River at— Page.
Nashville, Tenn.:
description 96
discharge..... 97
gage heights..... 97
Cumberland River drainage basin:
description 96
Davidsons River, N. C.
Avery Creek at:
description 110–111
discharge..... 111
Davidsons River near:
description 109
discharge..... 109
gage heights..... 111
Davidsons River near—
Davidsons River, N. C.:
description 109
discharge..... 109
gage heights..... 111
Delphi, Ind.
Tippecanoe River near:
description 4
discharge..... 5
discharge, monthly..... 6
gage heights..... 5
rating table..... 6
Desplaines River near—
Channahon, Ill.:
description 39–41
discharge..... 41
discharge, monthly..... 43
gage heights..... 42
rating table..... 43
Doe River at—
Elizabethton, Tenn.:
description 128
discharge..... 129
Duck River at—
Columbia, Tenn.:
description 153
discharge..... 154
gage heights..... 154
Eau Claire, Wis.
Chippewa River near:
description 20
discharge..... 21
discharge, monthly..... 22
gage heights..... 21
rating table..... 22
Eel River (lower) near—
Cataract, Ind.:
description 37–39
gage heights..... 38
Elizabethton, Tenn.
Doe River at:
description 128
discharge..... 129
Watauga River near:
description 126–127
discharge..... 127
discharge, monthly 128
gage heights..... 128
rating table..... 128

Elk River near— Page.
Elkmont, Ala.:
description 150–151
discharge..... 151
discharge, monthly 152
gage heights..... 151
rating table..... 152
Prospect, Tenn.:
description 157
discharge..... 157
Elkmont, Ala.
Elk River near:
description 150–151
discharge..... 151
discharge, monthly 152
gage heights..... 151
rating table..... 152
Fayette, W. Va.
New River at:
description 68–69
discharge, monthly 70
gage heights..... 69
Fightingtown Creek at and near—
Blueridge, Ga.:
description 157
discharge..... 157
McCays, Tenn.:
description 148–149
discharge..... 149
Flambeau River near—
Ladysmith, Wis.:
description 22–23
discharge..... 23
discharge, monthly..... 25
gage heights..... 24
rating table..... 24
Flint River at and near—
Brownsboro, Ala.:
description 150
discharge..... 150
New Decatur, Ala.:
description 157
discharge..... 157
Franklin, N. C.
Little Tennessee River at and near:
description 155
discharge..... 155
French Broad River at and near—
Alexander, N. C.:
description 155
discharge..... 156
Asheville, N. C.:
description 99–100, 100–101
discharge..... 100, 101
Horseshoe, N. C.:
description 98–99
discharge..... 99
gage heights..... 99
Newport, Tenn.:
description 101–102
discharge..... 102
discharge, monthly..... 103
gage heights..... 102
rating table..... 103
Oldtown, Tenn.:
description 101–102
discharge..... 102
French Broad River at and near— Page.
Oldtown, Tenn.—Continued.
discharge, monthly 103
gage heights..... 102
rating table..... 103
Friendsville, Md.
Youghiogheny River at:
description 54
discharge..... 54
discharge, monthly..... 56
gage heights..... 55
rating table..... 55
Greenbrier River at—
Alderson, W. Va.:
description 70–71
discharge 71
discharge, monthly..... 73
gage heights..... 72
rating table 72
Greeneville, Tenn.
Nolichucky River near:
description 119–120
discharge..... 120
discharge, monthly..... 121
gage heights..... 120
rating table..... 121
Hanging Dog Creek near—
Murphy, N. C.:
description 156
discharge..... 156
Havana, Ill.
Illinois River near:
discharge..... 44
Hiwassee River at—
Murphy, N. C.:
description 135–136
discharge..... 136
discharge, monthly..... 138
gage heights..... 137
rating table..... 137
Reliance, Tenn.:
description 138–139
discharge..... 139
discharge, monthly..... 141
gage heights..... 140
rating table..... 140
Holston River near—
Rogersville, Tenn.:
description 124
discharge..... 125
discharge, monthly..... 126
gage heights..... 125
rating table..... 125
Holston River (South Fork) at and near—
Bluff City, Tenn.:
description 122, 154
discharge..... 122, 155
discharge, monthly..... 124
gage heights..... 123
rating table..... 123
Horseshoe, N. C.
French Broad River at:
description 98–99
discharge..... 99
gage heights..... 99

Illinois River at and near— Page.
Havana, Ill.:
discharge 44
Minooka, Ill.:
description 35
discharge 35
discharge, monthly 37
gage heights 36
rating table 36
Ottawa, Ill.:
description 37–38
discharge 38
gage heights 38
Peoria, Ill.:
description 39
discharge 39
gage heights 40
Illinois River drainage basin:
description 34
Indianapolis, Ind.
White River (West Branch) at:
description 89
discharge 89
discharge, monthly 91
gage heights 90
rating table 90
Iuka, Miss.
Big Bear Creek near:
description 157
discharge 157
Jamestown, N. Y.
Chadakoin River at:
description 48
discharge 48
gage heights 49
Jasper, Tenn.
Sequatchie River near:
description 156
discharge 156
Judson, N. C.
Little Tennessee River at:
description 130
discharge 131
discharge, monthly 132
gage heights 131
rating table 132
Kanawha River drainage basin:
description 65–66
Kiskiminitas River at—
Salina, Pa.:
description 49–50
discharge 50
gage heights *50
Kittanning, Pa.
Allegheny River at:
description 47
discharge 47
gage heights 47
Knoxville, Tenn.
Tennessee River near:
description 104–105
discharge 105
discharge, monthly 107
gage heights 106
rating table 106
Ladysmith, Wis. Page.
Flambeau River near:
description 22–23
discharge 23
discharge, monthly 25
gage heights 24
rating table 24
Laurel Hill Creek at—
Confluence, Pa.:
description 58–59
discharge 59
gage heights 59
Licking River at—
Pleasant Valley, Ohio:
description 63
discharge 63
discharge, monthly 65
gage heights 64
rating tables 64–65
Little Miami River drainage basin:
description 80
Little River at—
Calhoun, N. C.:
description 111
discharge 111
Little Tennessee River at and near—
Franklin, N. C.:
description 135
discharge 136
Judson, N. C.:
description 130
discharge 131
discharge, monthly 132
gage heights 131
rating table 132
Logansport, Ind.
Wabash River at:
description 83–84
discharge 84
discharge, monthly 86
gage heights 85
rating table 85
McCays, Tenn.
Fightingtown Creek at.
description 148–149
discharge 149
Ocoee River at:
description 146
discharge 147
discharge, monthly 148
gage heights 147
rating table 148
Mad River near—
Springfield, Ohio:
description 60
discharge 61
gage heights 61
Mahoning River at—
Youngstown, Ohio:
description 60
discharge 60
discharge, monthly 62
gage heights 61
rating table 61
Mahoning River drainage basin:
description 59–60

Merrill, Wis. Page.
Wisconsin River at:
description 25–26
discharge..... 26
discharge, monthly..... 28
gage heights..... 27
rating table 27
Mills River (North Fork) at—
Pinkbed, N. C.:
description 112
discharge..... 112
discharge, monthly..... 114
gage heights..... 113
rating table 113
Mills River (South Fork) near—
Sitton, N. C.:
description 114
discharge..... 115
discharge, monthly..... 116
gage heights..... 115
rating table 116
Minooka, Ill.
Illinois River near:
description 35
discharge..... 35
discharge, monthly..... 37
gage heights..... 36
rating table 36
Mississippi River near—
Sauk Rapids, Minn.:
description 18
discharge..... 19
gage heights..... 19
Monongahela River drainage basin:
description 51–52
Morgantown, W. Va.
Cheat River near:
description 52
discharge..... 53
gage heights..... 53
Murphy, N. C.
Hanging Dog Creek near:
description 156
discharge..... 156
Hiwassee River at:
description 135–136
discharge..... 136
discharge, monthly 138
gage height 137
rating table 137
Muskingum River drainage basin:
description 62
Nantahala, N. C.
Nantahala River near:
description 155
discharge..... 156
Nantahala River near—
Nantahala, N. C.:
description 155
discharge..... 156
Nashville, Tenn.
Cumberland River at:
description 96
discharge..... 97
gage heights..... 97
Necedah, Wis. Page.
Wisconsin River near:
description 28–29
discharge..... 29
discharge, monthly..... 31
gage heights..... 30
rating table..... 30
New Decatur, Ala.
Flint River near:
description 157
discharge..... 157
New River at—
Fayette, W. Va.:
description 68–69
discharge, monthly..... 70
gage heights..... 69
Radford, Va.:
description 66–67
discharge..... 67
discharge, monthly..... 68
gage heights..... 67
rating table..... 68
Newport, Tenn.
French Broad River near:
description 101–102
discharge..... 102
discharge, monthly..... 103
gage heights..... 102
rating table..... 103
Pigeon River at and near:
description 116–117, 155
discharge..... 117, 155
discharge, monthly 119
gage heights..... 118
rating table 118
Nolichucky River near—
Greeneville, Tenn.:
description 119–120
discharge..... 120
discharge, monthly 121
gage heights..... 120
rating table 121
Nottely River near—
Ranger, N. C.:
description 143–144
discharge..... 144
discharge, monthly 145
gage heights..... 144
rating table 145
Ocoee River at—
McCays, Tenn.:
description 146
discharge..... 147
discharge, monthly 148
gage heights..... 147
rating table 148
Oldtown, Tenn.
French Broad River at:
description 101–102
discharge..... 102
discharge, monthly 103
gage heights..... 102
rating table 103
Olentangy River near—
Columbus, Ohio:
description 77
discharge..... 77

	Page.
Olentangy River near—	
Columbus, Ohio—Continued.	
discharge, monthly	79
gage heights	78
rating tables	78–79
Ottawa, Ill.	
Illinois River at:	
description	37–38
discharge	38
gage heights	38
Paint Rock River near—	
Paintrock, Ala.:	
description	149
discharge	149
Paintrock, Ala.	
Paint Rock River near:	
description	149
discharge	149
Peoria, Ill.	
Illinois River near:	
description	39
discharge	39
gage heights	40
Pigeon River at and near—	
Newport, Tenn.:	
description	116–117, 155
discharge	117, 155
discharge, monthly	119
gage heights	118
rating table	118
Pinkbed, N. C.	
Mills River (North Fork) at:	
description	112
discharge	112
discharge, monthly	114
gage heights	113
rating table	113
Pleasant Valley, Ohio.	
Licking River at:	
description	63
discharge	63
discharge, monthly	65
gage heights	64
rating tables	64–65
Prospect, Tenn.	
Elk River near:	
description	157
discharge	157
Radford, Va.	
New River at:	
description	66–67
discharge	67
discharge, monthly	68
gage heights	67
rating table	68
Ranger, N. C.	
Nottely River near:	
description	143–144
discharge	144
discharge, monthly	145
gage heights	144
rating table	145
Redhouse, N. Y.	
Allegheny River at:	
description	45–46
discharge	46
gage heights	46
Reliance, Tenn.	
Hiwassee River at:	
description	138–139
discharge	139
discharge, monthly	141
gage heights	140
rating table	140
Roane Creek at—	
Butler, Tenn.:	
description	154
discharge	154
Rock River at—	
Rockton, Ill.:	
description	31–32
discharge	32
discharge, monthly	34
gage heights	33
rating table	33
Rock River drainage basin:	
description	31
Rockton, Ill.	
Rock River at:	
description	31–32
discharge	32
discharge, monthly	34
gage heights	33
rating table	33
Rogersville, Tenn.	
Holston River near:	
description	124
discharge	125
discharge, monthly	126
gage heights	125
rating table	125
Salina, Pa.	
Kiskiminitas River at:	
description	49–50
discharge	50
gage heights	50
Sauk Rapids, Minn.	
Mississippi River near:	
description	18
discharge	19
gage heights	19
Scioto River near—	
Columbus, Ohio:	
description	74
discharge	75
discharge, monthly	76
gage heights	75
rating table	76
Scioto River drainage basin:	
description	74
Sequatchie River near—	
Jasper, Tenn.:	
description	176
discharge	176
Shoals, Ind.	
White River (East Branch) at:	
description	96
discharge	96
discharge, monthly	96
gage heights	94
rating table	95

Sitton, N. C. Page.
Mills River (South Fork) near:
description 114
discharge..... 115
discharge, monthly..... 116
gage heights..... 115
rating table 116
South Pittsburg, Tenn.
Battle Creek near:
description 156
discharge..... 156
Spring Creek at—
Tuscumbia, Ala.:
description 157
discharge..... 157
Springfield, Ohio.
Mad River near:
description 80
discharge..... 81
gage heights..... 81
Swannanoa River at—
Biltmore, N. C.:
description 104
discharge..... 104
Tennessee River at and near—
Chattanooga, Tenn.:
description 107–108
discharge..... 108
gage heights..... 108
Knoxville, Tenn.:
description 104–105
discharge..... 105
discharge, monthly 107
gage heights..... 106
rating table..... 106
Tennessee River drainage basin:
description 98
Tippecanoe River near—
Delphi, Ind.:
description 86
discharge..... 87
discharge, monthly..... 88
gage heights..... 87
rating table..... 88
Toccoa River near—
Blueridge, Ga.:
description 156
discharge..... 156
Tomotla, N. C.
Valley River at:
description 141
discharge..... 142
discharge, monthly..... 143
gage heights..... 142
rating table..... 142
Tuckasegee River at—
Bryson, N. C.:
description 133
discharge..... 134
discharge, monthly..... 135
gage heights..... 134
rating table..... 135
Tuscumbia, Ala.
Big Spring at:
description 152
discharge..... 153
Tuscumbia, Ala.—Continued. Page.
Spring Creek at:
description 157
discharge..... 157
Valley River at—
Tomotla, N. C.:
description 141
discharge..... 142
discharge, monthly..... 143
gage heights..... 142
rating table..... 142
Wabash River at—
Logansport, Ind.:
description 83–84
discharge..... 84
discharge, monthly..... 86
gage heights..... 85
rating table..... 85
Wabash River drainage basin:
description 82–83
Watauga, Tenn.
Watauga River at:
description 154
discharge..... 154
Watauga River at and near—
Elizabethton, Tenn.:
description 126–127
discharge..... 127
discharge, monthly 129
gage heights..... 128
rating table..... 128
Watauga, Tenn.:
description 154
discharge..... 154
White River (East Branch) at—
Shoals, Ind.:
description 93
discharge..... 93
discharge, monthly..... 95
gage heights..... 94
rating table 95
White River (West Branch) at—
Indianapolis, Ind.:
description 89
discharge..... 89
discharge, monthly..... 91
gage heights..... 90
rating table..... 90
Wisconsin River at and near—
Merrill, Wis.:
description 25–26
discharge..... 26
discharge, monthly..... 28
gage heights..... 27
rating table..... 27
Necedah, Wis.:
description 28–29
discharge..... 29
discharge, monthly..... 31
gage heights..... 30
rating table..... 30
Wisconsin River drainage basin:
description 25
Yazoo City, Miss.:
Yazoo River at:
description 158
discharge..... 159

	Page.
Yazoo City, Miss.—Continued.	
Yazoo River at—Continued.	
discharge, monthly	160
gage heights	159
rating table	160
Yazoo River at—	
Yazoo City, Miss.:	
description	158
discharge	159
discharge, monthly	160
gage heights	159
rating table	160
Yazoo River drainage basin:	
description	157
Youghiogheny River at and near—	
Confluence, Pa.:	
description	56
Youghiogheny River at and near—	Page.
Confluence, Pa.—Continued.	
discharge	57
gage heights	57
Friendsville, Md.:	
description	54
discharge	54
discharge, monthly	56
gage heights	55
rating table	55
Youngstown, Ohio.	
Mahoning River at:	
description	60
discharge	60
discharge, monthly	62
gage heights	61
rating table	61

O

PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Water-Supply Paper No. 128.]

The publications of the United States Geological Survey consist of (1) Annual Reports; (2) Monographs; (3) Professional Papers; (4) Bulletins; (5) Mineral Resources; (6) Water-Supply and Irrigation Papers; (7) Topographic Atlas of United States, folios and separate sheets thereof; (8) Geologic Atlas of United States, folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

The Professional Papers, Bulletins, and Water-Supply Papers treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous; H, Forestry; I, Irrigation; J, Water storage; K, Pumping water; L, Quality of water; M, General hydrographic investigations; N, Water power; O, Underground waters; P, Hydrographic progress reports.

Most of the above publications may be obtained or consulted in the following ways:

1. A limited number are delivered to the Director of the Survey, from whom they may be obtained, free of charge (except classes 2, 7, and 8), on application.

2. Every member of Congress is allotted a certain number, from whom they may be obtained, free of charge, on application.

3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they may be had at practically cost.

4. Copies of all Government publications are furnished to the principal public libraries in the large cities throughout the United States, where they may be consulted by those interested.

Series P.—The hydrographic progress reports contain the results of stream measurements. A report is issued for every calendar year, containing the results of data collected during that year. These reports were first published as a part of the Director's annual report or as a bulletin; they are now published as water-supply and irrigation papers. The following is a list, by years, of the publications containing the progress reports of stream measurements. A detailed index of these reports is published as Water-Supply Paper No. 119.

1888. Tenth Annual Report, Part II.
1889. Eleventh Annual Report, Part II.
1890. Twelfth Annual Report, Part II.
1891. Thirteenth Annual Report, Part III.
1892. Fourteenth Annual Report, Part II.
1893. Bulletin No. 131.
1894. Bulletin No. 131; Sixteenth Annual Report, Part II.
1895. Bulletin No. 140.
1896. Water-Supply Paper No. 11; Eighteenth Annual Report, Part IV.
1897. Water-Supply Papers Nos. 15 and 16; Nineteenth Annual Report. Part IV.
1898. Water-Supply Papers Nos. 27 and 28; Twentieth Annual Report, Part IV.
1899. Water-Supply Papers Nos. 35, 36, 37, 38, and 39; Twenty-first Annual Report, Part IV.
1900. Water-Supply Papers Nos. 47, 48, 49, 50, 51, and 52; Twenty-second Annual Report, Part IV.
1901. East of Mississippi River, Water-Supply Papers Nos. 65 and 75.
West of Mississippi River, Water-Supply Papers Nos. 66 and 75.
1902. East of Mississippi River, Water-Supply Papers Nos. 82 and 83.
West of Mississippi River, Water-Supply Papers Nos. 84 and 85.

1903. East of Mississippi River, Water-Supply Papers Nos. 97 and 98.
West of Mississippi River, Water-Supply Papers Nos. 99 and 100.
1904. East of Mississippi River, Water-Supply Papers Nos. 124, 125, 126, 127, 128, and 129.
West of Mississippi River, Water-Supply Papers Nos. 130, 131, 132, 133, 134, and 135.

The Geological Survey and the Reclamation Service have suboffices in different parts of the United States, from which hydrographic and reclamation work in the respective localities is carried on and where data may be obtained on application. These offices are located as follows:

Boston, Mass., 6 Beacon street; Utica, N. Y., 75 Arcade; Atlanta, Ga., 409 Temple court; Austin, Tex., University of Texas; Chicago, Ill., Federal Building; Belle Fourche, S. Dak.; Cody, Wyo.; Denver, Colo., Chamber of Commerce Building; Salt Lake, Utah; Los Angeles, Cal., 1108 Braly Building; San Francisco, Cal., 422 Merchants' Exchange Building; Phoenix, Ariz.; Carlsbad, N. Mex.; El Paso, Tex.; Billings, Mont.; Great Falls, Mont.; Hazen, Nev.; Boise, Idaho; Spokane, Wash., 424 Peyton Block; Pendleton, Oreg.

Correspondence should be addressed to

THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, D. C.

MAY, 1905.

LIBRARY CATALOGUE SLIPS.

[Mount each slip upon a separate card, placing the subject at the top of the second slip. The name of the series should not be repeated on the series card, but the additional numbers should be added, as received, to the first entry.]

Author.

U. S. Geological Survey.

. . . Report of progress of stream measurements for the calendar year 1904. Prepared under the direction of F. H. Newell by M. R. Hall, E. Johnson, jr., and John C. Hoyt. Pt. V.—Eastern Mississippi River drainage. Washington, Gov't print. off., 1905.

168, iii p. illus. II pl. (incl. map) 23cm. (U. S. Geological survey. Water-supply and irrigation paper no. 128)

Subject series: P, Hydrographic progress reports, 33.

1. Stream measurements. 2. Rivers—U. S. I. Hall, M. R. II. Johnson, E., jr. III. Hoyt, John Clayton, 1874.

Subject.

U. S. Geological Survey.

. . . Report of progress of stream measurements for the calendar year 1904. Prepared under the direction of F. H. Newell by M. R. Hall, E. Johnson, jr., and John C. Hoyt. Pt. V.—Eastern Mississippi River drainage. Washington, Gov't print. off., 1905.

168, iii p. illus. II pl. (incl. map) 23cm. (U. S. Geological survey. Water-supply and irrigation paper no. 128)

Subject series: P, hydrographic progress reports, 33.

1. Stream measurements. 2. Rivers—U. S. I. Hall, M. R. II. Johnson, E., jr. III. Hoyt, John Clayton, 1874.

Series.

U. S. Geological survey.

Water-supply and irrigation papers.

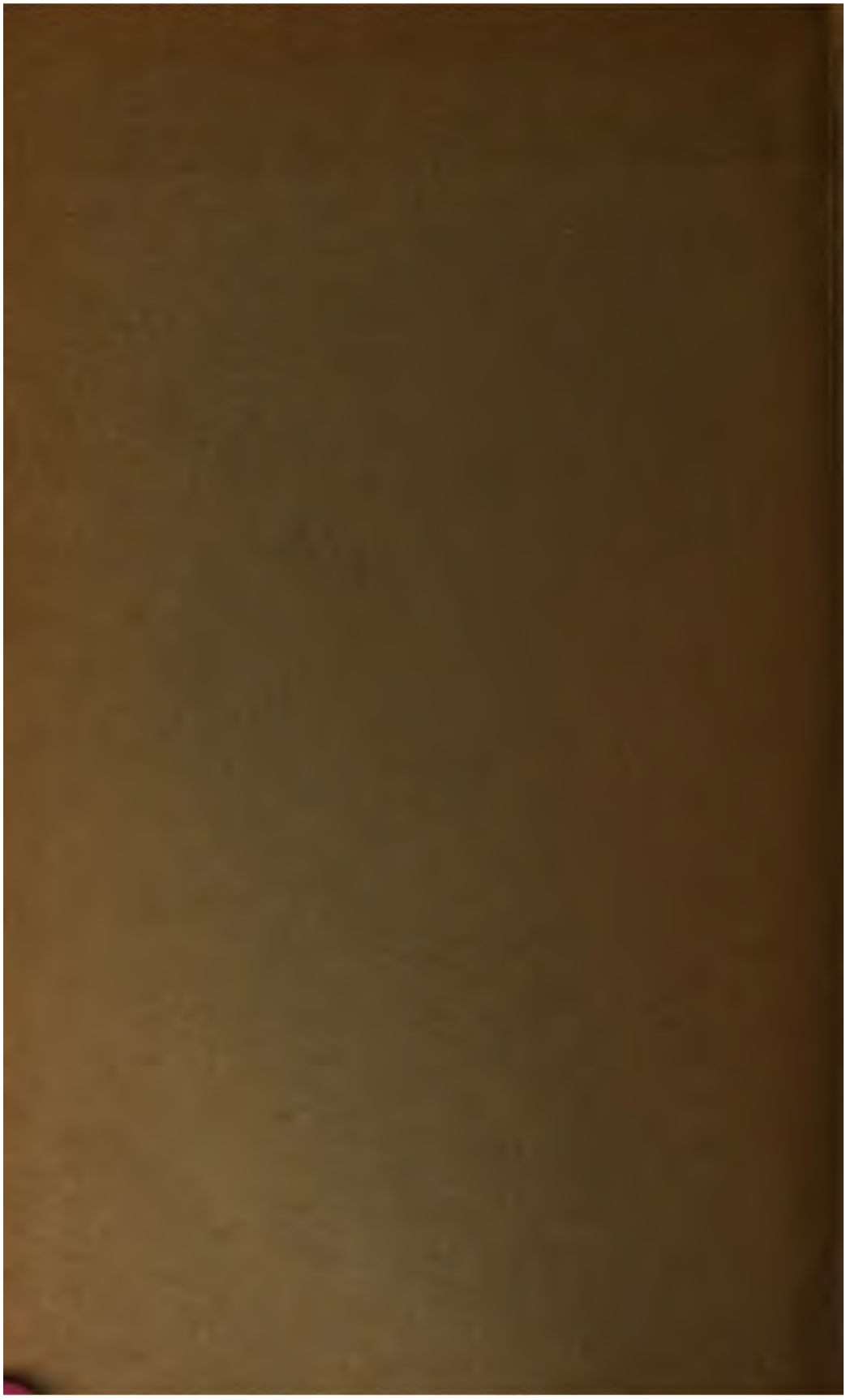
no. 128. Report of progress of stream measurements for . . . 1904 . . . by M. R. Hall, E. Johnson, jr., and J. C. Hoyt. Part V. 1905.

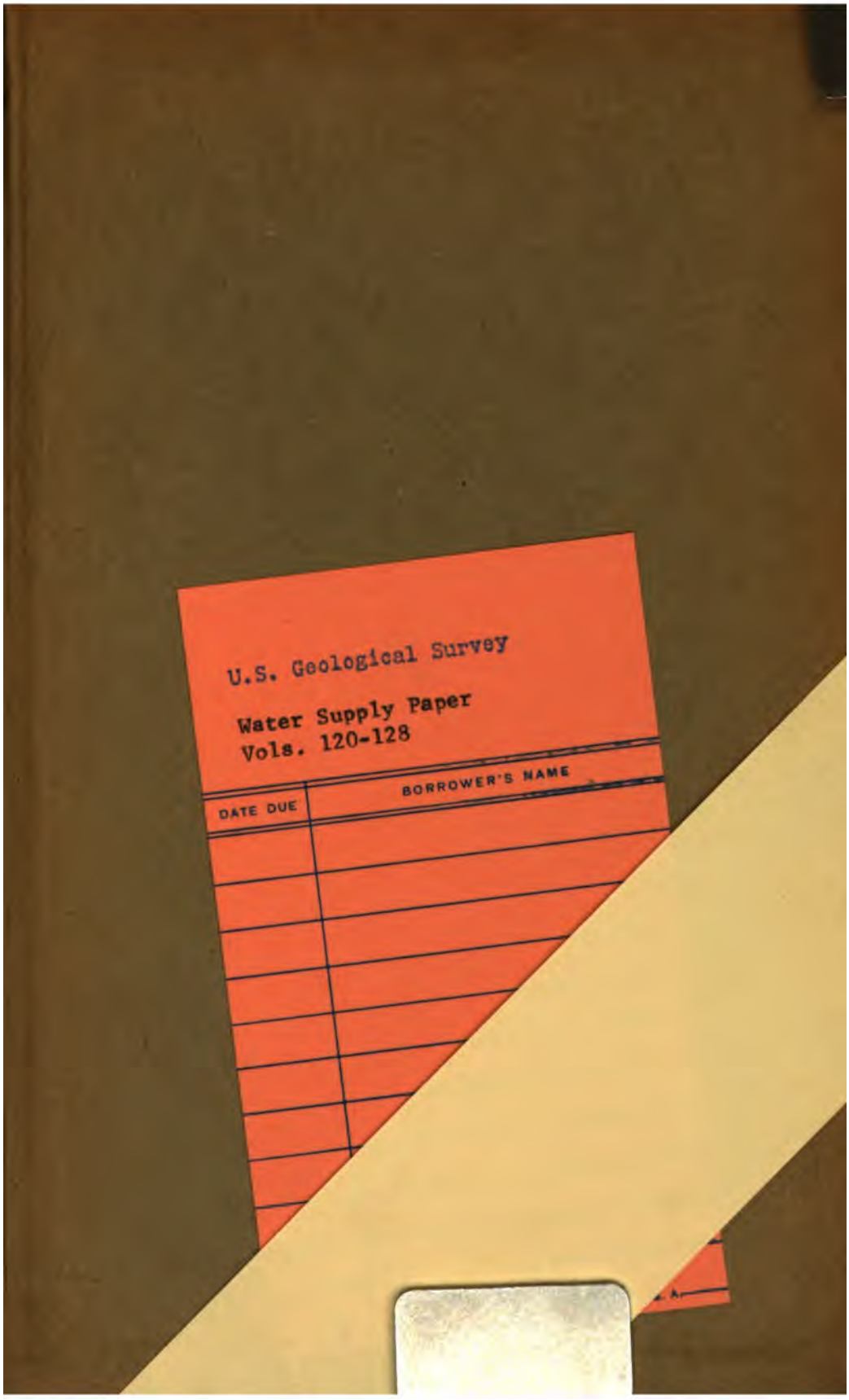
Reference.

U. S. Dept. of the Interior

see also

U. S. Geological survey.




U.S. Geological Survey
Water Supply Paper
Vols. 120-128
DATE DUE
BORROWER'S NAME

3 2044 102 942 240